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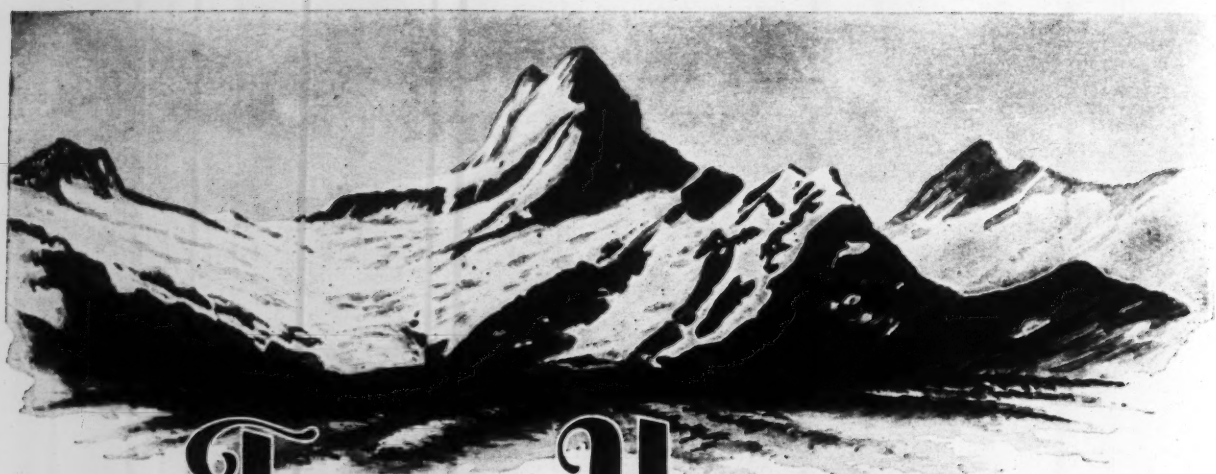

FIFTY YEARS

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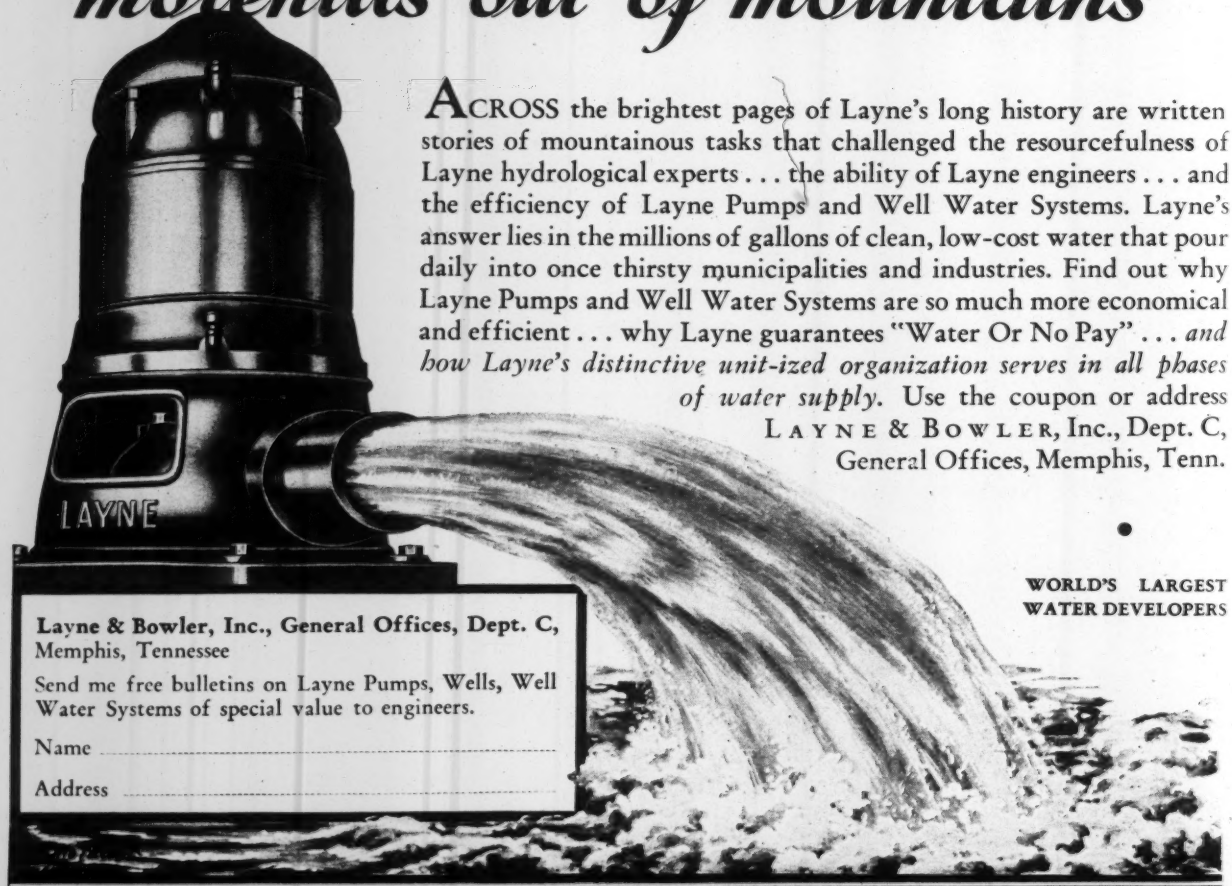

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Engineering News-Record

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Chicago's Waterworks—

A Century of Accomplishment

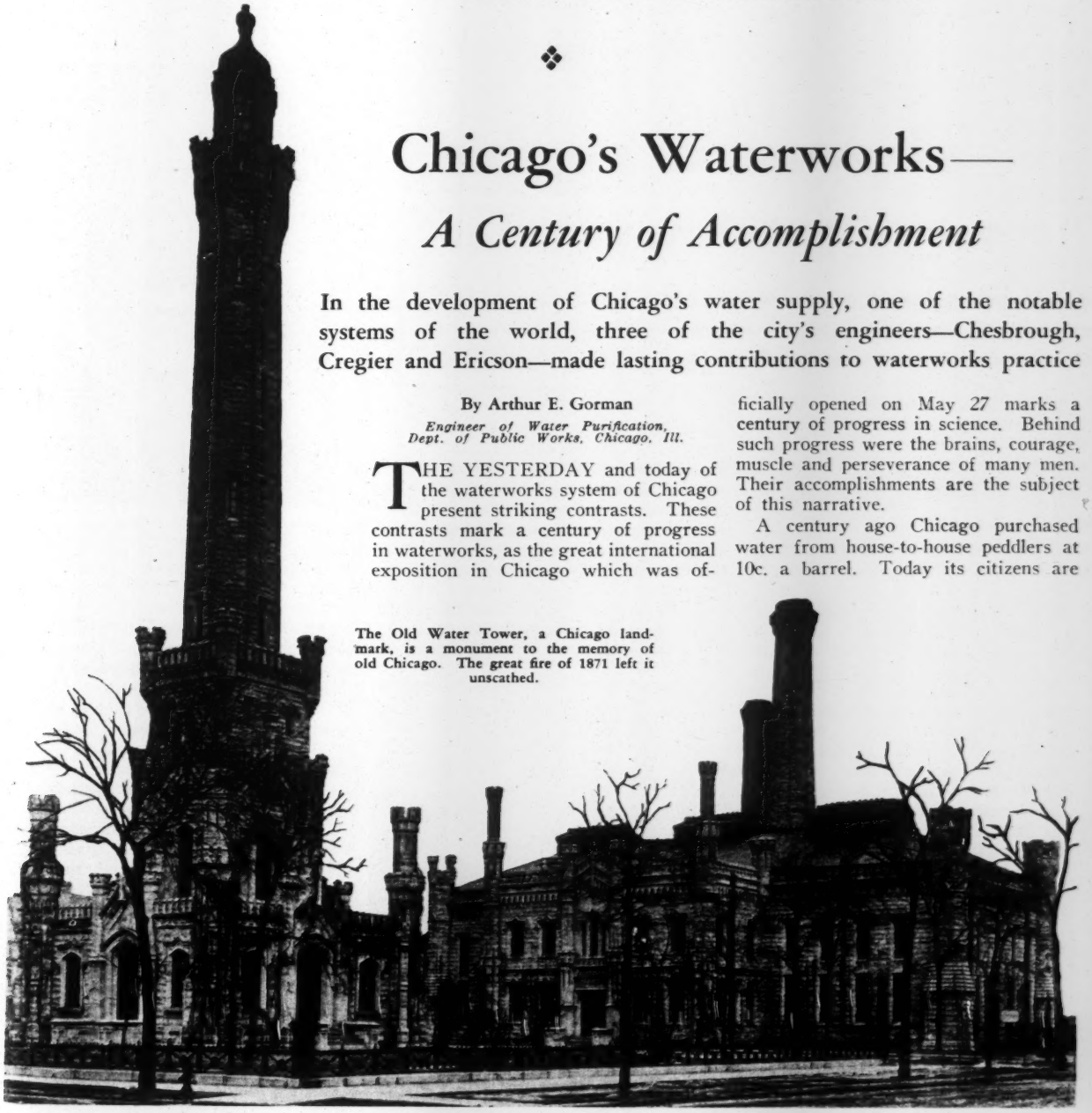
In the development of Chicago's water supply, one of the notable systems of the world, three of the city's engineers—Chesbrough, Cregier and Ericson—made lasting contributions to waterworks practice

By Arthur E. Gorman

Engineer of Water Purification, Dept. of Public Works, Chicago, Ill.

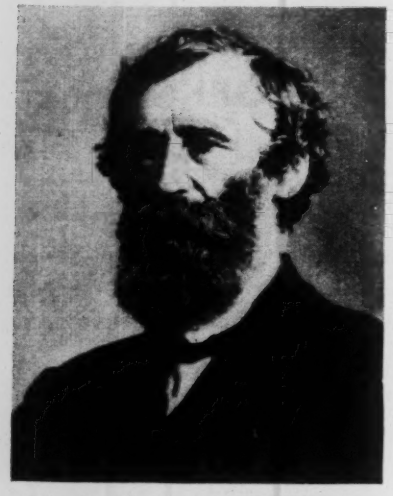
THE YESTERDAY and today of the waterworks system of Chicago present striking contrasts. These contrasts mark a century of progress in waterworks, as the great international exposition in Chicago which was officially opened on May 27 marks a century of progress in science. Behind such progress were the brains, courage, muscle and perseverance of many men. Their accomplishments are the subject of this narrative.

A century ago Chicago purchased water from house-to-house peddlers at 10c. a barrel. Today its citizens are



The Old Water Tower, a Chicago landmark, is a monument to the memory of old Chicago. The great fire of 1871 left it unscathed.

stockholders in a utility system that pumps more water than any other municipal waterworks in the world. The 10c. their forefathers paid the water peddler will now furnish 30 times that amount of water at convenient outlets in their homes. The tiny but sturdy donkeys that hauled away in carts the stiff blue clay from the first water tunnel under the lake are long since gone. Electrically operated trains loaded with rock, blasted at a single shot, now shuttle back and forth in driving the tunnels, 200 ft. below Lake Michigan. Hand labor in tunneling has largely disappeared, superseded by air drilling and machine mucking. The original steam engine of 25 hp., whose power not only pumped water to the homes of the pioneers but also ground their flour, has been succeeded by service at twelve pumping stations, pumping 1,000 mil-



Ellis S. Chesbrough, 1813-1886, first builder of tunnels for Chicago, nationally known consulting civil engineer.

lion gallons daily. The 2 miles of bored-cedar-log mains that served a limited portion of the city in 1842 have been replaced by more than 3,700 miles of cast-iron pipe, enough to reach from Chicago to Nome, Alaska. The pick-and-shovel regiments of men digging and refilling ditches have given way to machine ditchers and mechanical trenching and filling equipment. Wreckers' torches have made junk of giant pumping engines, which have been replaced by smaller centrifugal pumps having greater capacity. Cholera and typhoid fever, which ran rampant through the '40's and '50's of the last century, have almost entirely disappeared. The Chicago River runs backwards and carries the sewage away from the lake.

These few highlights in the history of Chicago's waterworks mark real progress. They testify to the work of men who with courage and fortitude and a limited knowledge of the laws of mechanics and biology struggled forward, meeting their daily tasks and planning heroically for the future.

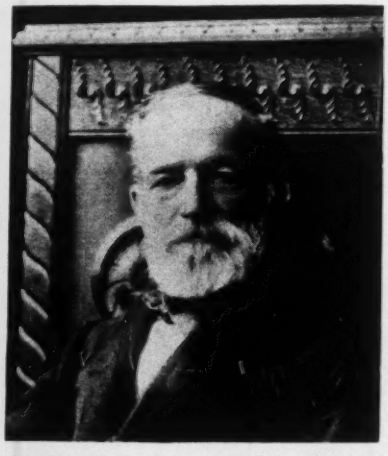
A review of Chicago's waterworks history brings out the names and work of many engineers and artisans. But in particular the service rendered and the responsibilities carried by three city engineers stand out above all others. To their memory and, through their recognition, to the memory of their contemporaries who cooperated to build the present Chicago waterworks, appropriate exercises are to be held on June 12, the opening day of the American Water Works Association convention in Chicago. With fitting ceremonies three bronze memorial plaques will be placed on Chicago's famous water tower. The names on the plaques will be:

	Born	Died
Ellis S. Chesbrough	July 6, 1813	Aug. 18, 1886
DeWitt C. Cregier	June 1, 1829	Nov. 9, 1898
John Ericson	Oct. 21, 1857	Apr. 16, 1927

A review of the services that these three men rendered to their city and to the waterworks profession as a whole, together with a record of the advancement in waterworks practice in the eras they represent, is timely. Each possessed the ability which won for him the confidence of his fellowmen and permitted him to carry great responsibilities.

All three were relatively young men when they were assigned to the task of directing the affairs of the Chicago waterworks, Chesbrough at 42, Cregier at 43 and Ericson at 40. Each contributed generously to the progress of the waterworks profession. Each received well-earned recognition from his professional peers. Chesbrough and Cregier were founder members in 1869 of the Civil Engineers Club of the Northwest, from which the Western Society of Engineers grew. Each served as president of the latter society, in 1873 and 1883 respectively. Mr. Chesbrough was president of the American Society of Civil Engineers in 1877. John Ericson was awarded the Chanute medal of the Western Society of Engineers in 1912. He was decorated in 1913 by the King of Sweden with the Royal Order of Vassa.

Obviously, these three men were not



DeWitt C. Cregier, 1829-1898, mechanical genius, designer of pumps, hydrants and waterworks equipment.

the only ones responsible for the great development of the Chicago waterworks system. Many others served in more or less subordinate capacities, doing important and intensive work through long periods of service. Ira Miltmore, a skilled mechanic of the early '40's, in spite of ridicule and many disappointments, succeeded in building and operating successfully in 1842 the first waterworks system in Chicago for the Chicago Hydraulic Co. William J. McAlpine came to Chicago from New York York City in 1851 to advise the young city of 35,000 on its first municipal waterworks system. He planned for a city of 100,000 in fifteen years, which was then considered an extravagant estimate but which was destined to fall short by 50,000. He recommended the location, pumping

John Ericson, 1857-1927, who welded into the distribution system the annexed suburban works and for 43 years kept the system ahead of the demands of the rapidly growing metropolis.

equipment, intakes and distribution system for the new municipal waterworks, chartered in 1851, at Chicago Ave. and the lake.

If a fourth man in addition to Messrs. Chesbrough, Cregier and Ericson were to be selected for outstanding service to the Chicago waterworks system, it would be Samuel G. Artingstall, who performed valuable services as Mr. Chesbrough's assistant in connection with the first lake tunnels, the Chicago Ave. pumping station and the West Side pumping station. He served two terms as city engineer, 1882 to 1887 and 1893 to 1894. He was chief engineer of the Sanitary District of Chicago in 1891. With Rudolph Herring and Benzette Williams, Mr. Artingstall was a member of the famous Drainage and Water Supply Commission appointed by Mayor Carter H. Harrison, Sr., in 1886, which submitted the classic report that led to the construction of the Chicago Drainage Canal.

To the memory and services of these and many others the three plaques are being dedicated in spirit, through recognition of the services of their respective chiefs.

Ellis S. Chesbrough will probable always be best known as the engineer who saw through to the finish the construction of Chicago's first water tunnel, 5 ft. in diameter. Begun in 1864, it was completed and dedicated for service on March 25, 1867. To testify to his ability and to the quality of the workmanship of those days, that tunnel is still in use. The same crib, located 2 miles from shore, is serving as an intake for the water supplied to the heart of Chicago today.

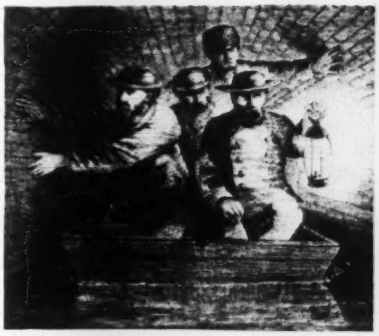
Born in Baltimore, at 18 he entered the field of engineering and served with the U. S. Army Engineers on various government and railroad projects, demonstrating unusual ability. In 1846, largely on the recommendation of his friend, J. B. Jervis, the noted consulting engineer on the Croton Aqueduct for the city of New York, he was offered the position of chief engineer of the western division of the Boston Waterworks, where he was largely responsible for the Brookline Reservoir project and the Cochituate project.

In 1855 Hon. William Ogden, president of the Chicago Sewerage Commission, succeeded in convincing Mr. Chesbrough of the opportunities for his special qualifications in Chicago, and on Oct. 1 he accepted the position of chief engineer of this commission. In 1860 he received a special assignment to make a detailed study of the water problem. At that time the pollution of the lake water by sewage was becoming alarming. There was every indication that pestilence would sweep the city unless a courageous stand were taken to improve the water supply. In 1864, after studying propositions for laying a 5-ft. iron pipe on the bed of the lake to an intake a mile from shore, a scheme for an infiltration gallery along the lake shore 5 miles north of the pumping station and a special intake in deep waters in the vicinity of Wilmette, with delivery conduit to this pumping station, Mr. Chesbrough finally recommended a tunnel to be dug through the blue clay under the lake to an intake 2 miles from shore, as the most practical means of obtaining a clean water for the city.

In the face of great opposition on the part of important citizens and even members of the newly organized Board of Public Works, his recognized ability and persuasive manner won approval for his tunnel project.

While agitation for this lake-tunnel project was at its height, the nation was turning all its energies to prosecution of the Civil War. When the contract was let, the surrender of Vicksburg and battle of Gettysburg had been written into history only three months.

On March 17, 1864, with fitting ceremonies, the shore shaft for the new tunnel was started. The pentagonal timber-crib designed and built under Mr. Chesbrough's direction, with the assistance of consultants, was successfully launched on July 24, 1865. With formal celebration on March 25, 1867, Chicago's first lake tunnel was dedicated to the people of the city and put into service. This was a historic day for Chicago, and the ceremonies were attended by dignitaries of the federal government, the state and city. All Europe was interested, and a drawing was sent on request to the Universal Exposition in Paris in 1867.



E. S. Chesbrough inspects the first Chicago waterworks tunnel under Lake Michigan on April 20, 1867. During the inspection trip, the boat tipped, the lantern went out and the quartette had to wade 600 ft. back to the shaft, according to *Harpers*, which in those days considered the building of the tunnel a feat of national importance.

No sooner had the new pumping station and tunnel been put into service than it became apparent that a second tunnel should be built, continuing under the city diagonally from the shore shaft to a pumping station on the West Side. The immediate occasion for this new project was the breaking in 1869 of a 36-in. main crossing the river, which deprived the West Side of water for many hours. Mr. Chesbrough recognized the danger of a river crossing, and his recommendation that pipes under the river be placed in tunnels was later adopted and is a policy rigorously followed by the city today. The new tunnel, 7 ft. in diameter and 31,490 ft. long, had as its intake a new shaft within the old crib. Begun July 12, 1872, it was completed in two years. Being under private property, it later interfered with foundations and piling for large buildings. Therefore its land section was abandoned in 1909 when the Blue Island Ave. tunnel was put into service.

The 16-ft. Chicago Ave. tunnel, latest concrete-lined conduit, may be contrasted with the 1867 Chesbrough 5-ft. brick-lined tunnel.

Mr. Chesbrough served continuously as chief engineer of the Board of Public Works and its successor, the Department of Public Works, as city engineer, from 1861 until Jan. 7, 1879, when he was made the first commissioner of public works. He resigned this position on May 18, 1879, to enter private engineering practice. In this capacity he served the cities of New Haven, Pittsburgh, Milwaukee, Jacksonville, Akron, New York, Boston, Cambridge, Providence, Peoria, Dubuque, Des Moines, Burlington, Chattanooga and Baltimore. In 1882 he was appointed permanent consulting engineer for New York on the Croton water supply and went to France and Spain to study high masonry dams. During this European trip he became dangerously ill. He died on Aug. 18, 1886, a comparatively poor man, leaving a widow and two sons.

DeWitt Clinton Cregier was born in New York City. At the age of 19 he was employed in the machine shop of the George W. Quintard Iron Works of that city, which later became the Morgan Iron Works. Five years later he came to Chicago to assist in the installation of "Old Sally," the first pumping engine at the new municipally owned waterworks. Serving as chief engineer of the North Side (Chicago Ave.) waterworks for 27 years, his ability as a designing engineer was indicated by the many patents he obtained on mechanical devices pertaining to waterworks use. Many of them were adopted by the City of Chicago without royalty fees. His design of the 36-m.g.d. pumping engine at the North Side pumping station, installed in 1872, is probably the best-known example of his ability. He was also the designer of a fire hydrant used as standard equipment in Chicago for a great many years. A number of these hydrants are still in service. (See *ENR*, May 9, 1918, p. 921.)

It was largely through Mr. Cregier's untiring efforts and ability that, following the great fire of 1871, which destroyed the North Side waterworks, this station was again put back into service after eight days.

When Mr. Chesbrough resigned as city engineer in 1879, Mr. Cregier was appointed in his place. Three years later he was appointed commissioner of public works and served in that office until he resigned on Jan. 31, 1886, to

In 1928 the first 54-in. cast-iron feeder main was laid in Chicago in Leavitt St. north of Eastwood Ave. Excellent ground permitted speedy work with a wide-cut trenching machine.

accept a position as superintendent of the West Chicago Street Railroad, the company that boasted of having 4,000 horses!

Chicago was then pumping in two average days as much water as it pumped in 1853, the first year of Cregier's service with the city. For further comparison, one month's pumping in 1932 was equivalent to one year's pumpage in 1886.

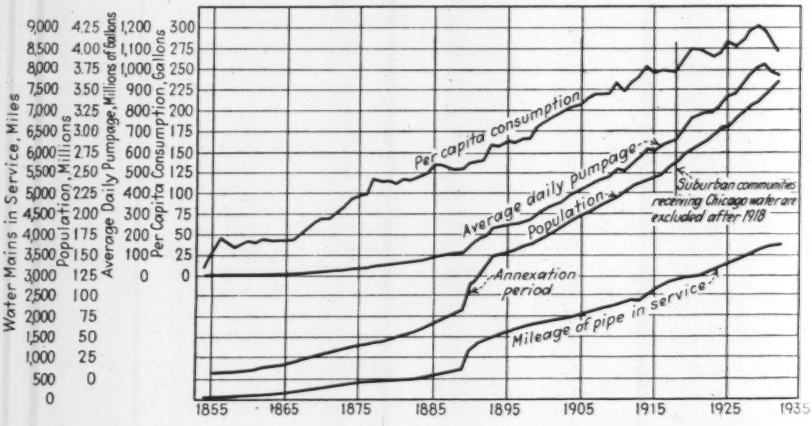
He dearly prized "Old Sally," that remarkable old engine that was the first owned and operated by the city. It outlived Mr. Cregier by six years. He saw the low-pressure, walking-beam engines known as '57 and '67 placed alongside of "Old Sally" to bring the capacity of the North Works up from 8 to 38 m.g.d. The Fort Pitt pumping engine of his own design boosted this capacity to 74 m.g.d. in 1872. One wonders what DeWitt Cregier would say if he could enter his North Side station today! All of his old pumps are gone. The work they once performed, now multiplied three and four times to meet present-day demands, is carried on by four 40-m.g.d. motor-driven centrifugal pumps, occupying but a modest space in the sub-basement of the building.

The first pair of Corliss compound condensing beam engines at the new West Side pumping station were installed in 1876 while Creiger was still chief of the North Works. To keep the water service up with demands, two more pumps of the same type were installed eight years later. The latter two are still standing at the 22d St. pumping station, though they have been idle for many years. This station, like the Chicago Ave. station, is now wholly electrically operated, with pumping equipment of the centrifugal type. This old West Side station is destined to pass into history in another year or two with its companions of many years, the 14th St. and Harrison St. stations. All three will be replaced shortly by one station on the site of the last named. This new station, the thirteenth in the Chicago system, will be equipped with six 50-m.g.d. modern motor-driven centrifugals.

In 1889 and 1890 five 18-m.g.d. vertical triple-expansion pumping engines were erected at the 14th St. and Harrison St. stations, while Mr. Cregier was mayor of Chicago. They were mighty engines, and no one dared estimate when they would become obsolete. They are operating today, but their performance record is no longer favorable, and they will soon be dismantled.

In 1889, the year Mr. Cregier was elected mayor of Chicago, the area of the city was increased, through annexation, from 36.76 to 169.84 sq. miles, and the population from 850,000 to 1,107,000. Mayor Cregier realized the necessity for a unified water system in the Chicago metropolitan area at that time and gave his endorsement and approval to the studies and plans for the extension of the waterworks system which started following these annexations.

Growth of the Chicago waterworks in extent of distribution system and in consumption, both in total and in per-capita rates, has kept pace with the increase of population.



It was during Mr. Cregier's office as mayor that the movement for the Columbian Exposition in Chicago was launched, and it received his wholehearted support. He served as one of the directors and was chairman of the committee on buildings and grounds. President Cleveland in 1894 appointed him as superintendent of U. S. Indian Warehouse in Chicago and special disbursing agent of public funds. He died on Nov. 9, 1898, leaving six sons and one daughter.

John Ericson received his technical training in his native city, Stockholm, Sweden, being graduated from the Royal Polytechnic Institute in 1880 with the degree of civil engineer. His first service in the Chicago area was as an engineer on the Illinois & Michigan Canal in 1883, at the age of 26. In 1884 he was employed by the city of Chicago as a draftsman on tunnel work.

To John Ericson fell the responsibility of welding together into one comprehensive waterworks unit the numerous stellite systems inherited by the city through annexation of suburba towns and villages. During the 3 years he was city engineer and th thirteen years he served the Chicag waterworks in subordinate capacities he demonstrated extraordinary engi neering skill and vision, and the resul is Chicago's present-day highly efficien waterworks. In this period the Chicag waterworks system increased from a single crib, 11 miles of tunnels, tw pumping stations and 533 miles of main to one of six intakes, 70 miles of tunnels, eleven pumping stations and 3,40 miles of cast-iron mains.

One of his first assignments was a investigation of the extent of pollution of the lake waters off the mouth of the Chicago river following the heavy rains of Feb. 8 to 10, 1887. This experience must have impressed him greatly, for all through his career with the city he showed great concern over the sanitary quality of the water supply. This is emphasized first by his special report in 1893 to the city engineer, S. G. Artingstall, urging a different location for the Hyde Park crib than the one that had been selected. He believed, and rightly so, that the drift of pollution from the Calumet River would be diverted by the Clark Point reef toward the proposed intake. Unfortunately his recommendation was not adopted.

The peak in Chicago's typhoid rate occurred in 1891, when it was 173.8 per 100,000. Mr. Ericson made a special investigation and became convinced that polluted water was responsible for this condition. Those were the days when at great expense universal publicity was being given to the Chicago World's Fair. There was much concern, both in the city and throughout the country, lest the exposition might be the focus for widespread typhoid-fever infection.

So serious were the rumors about Chicago's water supply that the exposi-

tion officials granted a water concession to the Waukesha Hygia Mineral Springs Co., which laid a 6¼-in. pipe line, 101 miles long, from the famous Waukesha Springs in southeastern Wisconsin to the fair grounds to supply safe water. Further, special Pasteur-Chamberlain filters were installed all over the fair grounds to improve the quality of the free city water available at numerous hydrants. The Waukesha water cost a penny a glass.

Impressed by the higher typhoid-fever rates in the Chicago Ave. pumping station districts, Mr. Ericson in another report to Mr. Artingstall in 1893 strongly recommended the extension of the 7-ft. tunnel, which had its crib intake in the northwest corner of the government breakwater, to the Two-Mile Crib. The intake was in a zone of serious pollution, and the tunnel was not giving a satisfactory water-supply service. Finally in 1895 it was extended in accordance with Mr. Ericson's recommendations.

It was under John Ericson that equipment for chlorination of Chicago's water supply, using calcium hypochlorite, was first installed at the Dunne Crib on March 15, 1912, and later chlorine at the pumping stations. During Mr. Ericson's 43 years of service the typhoid-fever rate in Chicago dropped from the peak of 173.8 cases per 100,000 in 1891 to 0.7 in 1927.

When he became city engineer he insisted that all cribs be located in the lake not less than 3 miles from shore, but persistently, year after year, he recommended filtration of Chicago's water supply. However, he realized that metering and filtration must go hand in hand as an economic program. He encouraged the movement to build an experimental filtration plant in Chicago. His broad plan for filtration is being carried out, and it is to be hoped that in the near future his memory may be further honored by the actual building of a filter plant for Chicago.

Chicago's first concrete-lined tunnel—the Blue Island Ave. tunnel—was constructed in 1907 and 1908. Incidentally, this tunnel was dewatered in April, 1932, after nearly 25 years of continuous service and was found to be in good physical condition. A special report on the internal accretions observed was published in *Engineering News-Record,* March 23, 1933, p. 374.

In building the Southwest Land Tunnel in 1906 Mr. Ericson inaugurated the policy of digging deep-rock tunnels. Under his régime the policy of building tunnels by city day labor instead of by contract was established.

During the three decades of his régime the swan song of triple-expansion displacement pumping engines was sung, and centrifugal pumps were adopted for Chicago. The first centrifugal pump was installed at the 22d St. pumping station in 1911. It is timely to note that the contractor for the foundation of this pump was the present city engineer, Myron B. Reynolds. At the time of Mr. Ericson's death in 1927 six of the eleven pumping stations were operating under normal capacities, using centrifugal pumping equipment.

Always an engineer and never a politician, his pleasing personality enabled him to get along well with politicians. With the exception of universal metering, for which he labored long and hard, he eventually convinced the various administrations of the soundness of his engineering recommendations, as the result of which the present highly efficient waterworks in Chicago was developed.

He organized an efficient engineering department in the city service, and his successors are carrying on his policies. Always interested in technical research of an engineering nature, he contributed many valuable papers to the technical press and engineering societies. He was instrumental in bringing the A.W.W.A. convention to Chicago in 1927, but died a few weeks before this convention opened. Mr. Ericson can truly be called the builder of Chicago's modern waterworks system.

Progress in Intake Design Revealed by Chicago Crib

Starting with a submerged pipe extending a short distance into Lake Michigan, Chicago has developed intake design through intermediate stages to that of great exposed structures several miles from shore

By Myron B. Reynolds
City Engineer, Bureau of Engineering, Department of Public Works, Chicago, Ill.

WITH an inexhaustible supply of fresh water at its front door, Chicago has had perhaps the greatest range in experience with intake cribs of any of the large American cities. It has required extraordinary patience and unusual engineering skill to obtain water from Lake Michigan without interruption of supply to meet the ever-mounting demands of the city. In 91 years its intake provisions have ranged from a 14-in. intake pipe, projecting but 150 ft. into the lake to submerged intake cribs several hundred feet from shore in deeper water, and finally to mammoth exposed intakes located 2 to 4 miles from shore, strong enough to meet the destructive force of driving storms.

In the construction and operation of these intakes waterworks engineers of Chicago have met with unusual problems. Conservative design practice has been followed, for the risks are great and the stakes are high. Lake storms have threatened destruction of every one of these cribs at one time or another, especially during the early construction stages. After trying experiences some contractors have given up, and it was necessary for the city to complete the structures.

Almost continuously, since the first exposed crib structure was built in Lake Michigan in 1865, Chicago engineers have either been building additional intakes or preparing plans and specifications for them. Today the city is served by six exposed crib intakes, is building a seventh, has dismantled one (1926) and has plans for wrecking its oldest crib when the new intake goes into service.

Perhaps the worst period in the history of Chicago waterworks, in so far as intake experiences are concerned, was during the early hours of Jan. 21, 1892. Due to unusually cold weather, low lake levels and extreme ice conditions, difficulties were experienced at every one of its intakes, and for many hours there was practically no water service in the city. The ports to the inner well of the Two-Mile Crib became clogged with ice that had entered through the opening on the west side of the protecting breakwater. This obstruction so limited the quantity of water entering the tunnels that it was only possible to supply the north, west and central pumping stations with enough water to keep the distribution system filled, there being practically no pressure in the system. Simultaneously intake difficulties developed at the Lake View and 68th St. submerged intakes, so that the north, south and central portions of the city experienced a water famine.

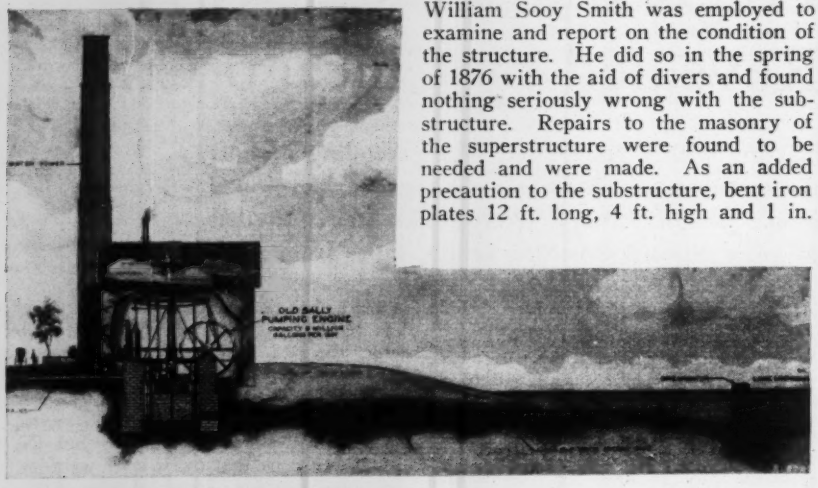
First pipe intake

Chicago's first waterworks, which was privately owned and built in 1842, had a 14-in. wrought-iron pipe extending into the lake about 150 ft. on a pier. When the installation was made sufficient consideration apparently had not been given to the possibility of a sudden lowering of the lake due to wind action and barometric pressures, for in its early months of operation interruptions of supply were frequent due to the end of the intake being out of water.

Chicago's second waterworks intake was for the municipally owned system, located at Chicago Ave. and the lake. It consisted of a wooden pipe projecting 600 ft. into the lake and terminating in an intake protected by stone and a timber breakwater. At both this and the earlier intake, difficulties were experienced with fish being drawn in through the inlet pipes at certain seasons of the year. At the second intake sand frequently piled up over the intake and materially affected its capacity. Submerged intakes never operated satisfactorily.

Timber cribs

In connection with the first lake-tunnel system, designed by Ellis S. Chesbrough, a timber crib was built. It was pentagonal in shape, the outer and inner dimensions of the crib being respectively 58 and 22 ft. on a side and 40 ft. high. It was built on a flooring of 12-in. white pine timber, the grillage being of the same material except that the upper 10 ft. of the outside was of white oak.



The water supply of Chicago in 1855 consisted of an 8-m.g.d. walking-beam pumping engine and a 9x4-ft. wood intake conduit extending 600 ft. into the lake. Fish and sand caused trouble.

This first crib had three rectangular port openings, 4 ft. wide and 5 ft. high through the breakwater at different depths from the surface of the lake, each entering wells within the breakwater 4 ft. square rising to the top of this structure. The crib was successfully launched July 24, 1865, and was towed to its place and with no great difficulty sunk in 33 ft. of water 10,000 ft. from shore. It was filled with loose rubble. As has been the history in the placing of all Chicago's cribs, a storm was encountered a few days later, and engineers were much concerned over the possibility of complete destruction of this crib. Fortunately, it was finally placed, the inner well was dewatered and the shaft of the tunnel, consisting of 9-ft.-diameter cast-iron sections, was successfully built. It was not intended at first to maintain a keeper on this crib, as it was expected that periodic attention to the marine light would be the only operating feature involved. But because of operating difficulties in the winter time a housing was placed over the crib, and since that time this practice has been followed in connection with all Chicago's intake structures, except those adjacent to other cribs so equipped.

The heavy investment that Chicago had made in its first water tunnel and intake gave city officials much concern over the safety of the intake structure, and unusual precautions were taken each year to repair damage made by storms during the winter.

After its first eight years in service alarming articles appeared in the press, and the public became very much excited over the safety of this crib. Gen. William Sooy Smith was employed to examine and report on the condition of the structure. He did so in the spring of 1876 with the aid of divers and found nothing seriously wrong with the substructure. Repairs to the masonry of the superstructure were found to be needed and were made. As an added precaution to the substructure, bent iron plates 12 ft. long, 4 ft. high and 1 in. thick were bolted to each angle of the timber near the top. In 1895 the city built a special breakwater around the crib to save it from possible destruction.

Four-Mile Crib

Chicago's second crib, the Four-Mile, was different in many respects from the first structure. It was located over twice as far into the lake (20,500 ft.) and in 40 ft. of water. There is a grillage of 12x12-in. timbers, 15 ft. high, which supports two concentric steel shells, 118 and 70 ft. in diameter. Radial bulkheads between these steel shells divide the structure into 24 compartments. Six ports were built in the grillage. To avoid having to cut through the timber floor of the crib for construction of the inner shaft, a 12-ft.-diameter hole was made during construction, and a cast-iron pipe was calked into place. This was used for the shaft opening.

The crib was loaded with stone to a 15-ft. draft and towed out into the lake on Sept. 14, 1889. It was sunk on Oct. 10. A 3-ft. concrete floor was poured into the bottom of the well. The steel is 6 ft. above mean lake level, and is surmounted by a 10-ft. coping wall and a 9-ft. parapet wall.

The other crib substructures, which the city built entirely of timber and stone, were the 68th St. and Lake View intakes, the latter having been dismantled in 1924. These structures were provided with intake ports near the bottom of the lake. Because of dangerous damage by storms during the winter of 1893 and 1894 it was necessary in 1895 to protect the 68th St. crib by an outer breakwater similar to that built for the first Two-Mile Crib. But in doing so, no surface opening was made, the ports being submerged, and the breakwater has given very satisfactory protection. An outer breakwater for the Lake View Crib was built in 1891.

The Carter Harrison and Edward F. Dunne cribs, built in 1897 and 1907 respectively are similar in general details to the Four-Mile Crib, having concentric steel shells, placed on timber grillage, with granite coping walls. They depart from the earlier design by having two inlet shafts to the tunnel instead of one, as at the Four-Mile Crib. In constructing the shaft for each of these cribs the floor was cut through instead of calking the shaft section in place originally.

Wilson Ave. Crib

The third stage in the development of crib structures in Chicago was in connection with the one at Wilson Ave., built in 1915. This was the first crib to be built with flotation chambers instead of a solid timber base. All previous cribs had solid timber bottoms of varying thickness to facilitate floating. Their center of gravity was high, and they were unstable in time of storms. Great difficulty was experienced in cutting through the wooden bottom in constructing the shaft.

The flotation chambers of the Wilson Ave. Crib were formed by placing wooden bulkheads over the ports and vertical cylinders between the inner and outer chambers. After the crib was completed and ready for use these bulkheads were removed. The outer steel shell was equipped with a cutting edge to make an effective seal in the clay of the lake bottom. The diameters of the two concentric shells are 90 and 40 ft. respectively. This crib was started in May, 1915. It was finished and sunk into place in 33.5 ft. of water 13,600 ft. from shore on Oct. 27, 1915.

The new William E. Dever Crib now under construction is similar in structural details to the Wilson Ave. Crib. It is Chicago's eighth exposed crib built in Lake Michigan. It will serve to protect the intake for the new Chicago Ave. tunnel now under construction, to serve the central and central west sections of Chicago. The concentric steel cylinders are 90 and 40 ft. in diameter and are made of $\frac{1}{2}$- and $\frac{3}{8}$-in. plates set vertically. The shells are 45 ft. high and are connected by sixteen radial diaphragms. There are eight intake tubes 8 ft. high and 10 ft. wide. Buoyancy chambers were made by bulkheads closing the intake ports, and others were built between the two concentric steel shells.

Artist's sketch of new Dever crib which is lined inside with stainless steel plates. The outer shell is to be decorated with patterns of modernistic design.

The erection of the substructure was begun in the early part of 1927 in the harbor south of the Navy Pier. In October of that year the steelwork was erected above the flotation line, and the crib was ready to launch, but due to delays in delivery of materials and the approach of the winter season the launching was postponed until the following year.

The crib was floated out to its permanent location on July 25, 1929, the valves in the buoyancy chambers were opened, and the crib was allowed to settle to bottom. Due to unforeseen ground conditions the crib settled unevenly. The crib shell was filled with concrete, and work on the 16-ft. intake shaft started in 1931. The concrete lining of the intake shaft was finished in December of that year.

The principal difference between the structures of the Wilson Ave. and Dever cribs is that the Wilson Ave. Crib superstructure consists of granite topped with brick, while the Dever Crib superstructure is of concrete incased within $\frac{3}{8}$-in. steel sheets. The inside of the new crib below the gallery will be lined with stainless steel sheets to a point about 1 ft. below the low-water level.

Externally this crib is to be different from all the others. Its steel outer shell will be painted with aluminum paint, and special external decorative patterns of modernistic design are provided, as illustrated in the accompanying artist's sketch.

Port velocities

The ratio of port area to tunnel area varies from 1.1 to 1, on the Two-Mile Crib, to 3.33 to 1 on the Wilson Ave. Crib. Originally the Two-Mile Crib served but a 5-ft.-diameter tunnel, and the ratio then was 3.27 to 1. When the second 7-ft. tunnel with its intake terminated in this crib, the ratio was reduced to 1.1 to 1. The third tunnel, 7 ft. in diameter, terminates between the crib and the protecting breakwater. For the 68th St. and Four-Mile Crib the ratio is practically 2 to 1. For the Carter Harrison Crib it is 2.28 to 1, and for the Dunne and the new Dever cribs 2.47 and 2.45 respectively.

As it is located adjacent to the Carter Harrison Crib, no provision has been made for living quarters on the Dever Crib. However, the structural steel has been designed to provide for installation of rooms and equipment for handling and storing of chlorine and other chemicals in case chemical treatment of the water at the intakes is decided on in the future.

Five of Chicago's present cribs have living quarters on them for the cribkeeper and his two assistants and cook. In winter, because of ice difficulties, the maintenance crew is increased to six men. In winter because of frazil ice, the screens at the intake shafts within the cribs are raised. The workmen on cold days and nights keep the ports clear and prevent ice cakes from entering the shaft. When a stoppage occurs in an intake port it can usually be broken up by the explosion of $\frac{1}{4}$ to $\frac{1}{2}$ stick of dynamite. In recent winters (1932-'33 excepted) intake troubles at the cribs have not been serious. Severe lake storms, however, did considerable damage to all cribs in 1929-'30-'31.

Special sanitary precautions are taken to prevent pollution of the water. All garbage and human wastes are destroyed by incineration. Liquid wastes from the kitchen and lavatories are discharged into a filter basin of sand and then pass through a sterilizing tank in which a supply of calcium hypo-chlorite is placed each day.

The latest development for Chicago's cribs is the proposed plan for installing complete equipment at the Edward F. Dunne Crib this summer for treating the water entering the shafts at this and the 68th St. Crib by ammonia and chlorine. The object of this innovation is to be prepared to eliminate chlorophenol tastes in the water on the South Side, and also to give prolonged contact between these chemicals and the treated water as an extra public health precaution againt sporadically heavy pollution of the lake waters by sewage ar industrial wastes from the Calumet region of Indiana.

CHICAGO INTAKE CRIBS

Crib	Built: Begun	Built: In Service	Distance of Crib From Shore, Ft.	Elevation of Lake Bed, Below Datum	Number of Ports	Elevation of Top of Ports, Below Datum	Total Effective Area of Ports, Sq.Ft.	Capacity of Crib at Velocity of 1 Ft. Per Sec., m.g.d.
Wilson	1915	1918	13,600	—33.5	7	—22.5	463.9	300
C. H. Harrison	1897	1900	13,830	—33.8	6	—22.6	178.7	115
Two-Mile	1864	1867	9,340	—29.0	4	N. Port —14.0 N.W. Port —14.0 W. Port — 1.5 E. Port — 2.0	64.0	41.3
					3*	— 4.0±	60.0	38.8
							Total 80.1	
Four-Mile	1889	1892	19,000	—38.0	4	—30.5	100.0	64.6
68th St.	1892	1894	10,525	—32.0	4	—16.0	77.0	49.8
E. F. Dunne	1907	1911	10,525	—32.0	8	—18.5	392.0	253.0
W. E. Dever	1927	....	13,880	—34.0	8	No. 1 Port —24.5 No. 5 Port —27.5	530.2	342.0

*Three gates in shaft between crib and breakwater.

Italy's Motor-Truck Road Nearing Completion

Final sections of Italy's new highway for the exclusive use of heavy motor-truck traffic between Milan and Genoa are nearing completion, and the truck route will soon be opened to through traffic.

Passenger automobiles will be forbidden use of the new highway, it is stated, as the road was planned for the use of heavy 10- to 15-ton motor trucks with trailers. When loaded to capacity, one of these trucks with its trailer weighs approximately 25 tons.

A special feature of the truck road, which differs from the ordinary Italian highway, is the increase in the radius of all turns to 100 meters, enabling trucks hauling two or three trailers to negotiate the curves without difficulty. The radius of turns on the present road is about 12 meters.

In the mountainous sections the general slope of the new highway will be about 4 per cent compared with a 9 per cent grade on the old road. Several tunnels ranging in length to 900 meters are also being opened through the mountains.

A great part of the new road is being rebuilt over the old highway, and plans call for the extension of the road around the larger cities so that the heavy trucks will not have to pass through them.

Advance in Pre-Treatment Aids Water Purification

Development of greater efficiency in preliminary treatment processes has featured the recent advance in water purification—Improved equipment and better understanding of processes involved have enhanced purification-plant performance

By N. T. Veatch
Of Black and Veatch, Consulting Engineers, Kansas City, Mo.

THE DEVELOPMENT of preliminary treatment is an outstanding feature of the general advance that water purification has made during the last decade. "The battle must be won in the basins" has long been an axiom among waterworks men, and the combined efforts of designers, operators, manufacturers of equipment and chemicals, chemists, bacteriologists and research workers have gone a long way toward making this possible.

The trend toward more efficient preliminary treatment is plainly reflected in the type of articles that have appeared in the technical press. The boundless faith in filtration, which characterized the period between 1910 and 1920, has been replaced by descriptions and discussion of methods for the creation of conditions favorable to filtration. Plant design previous to 1920 was centered largely around the filters, but recently the filter is considered to be only one of several important features.

Recent advances in preliminary treatment have been made in the fields of operation, design and manufacture. Discussion to best advantage is found in following the various steps through the modern plant.

Initial processes

Screens—Previous to the development of self-cleaning intake screens of relatively fine mesh, much objectionable matter, including fish life, was commonly brought into the treatment plant with the raw water. An additional burden was placed on basin operation, since the volume of sludge as well as its putrescibility was thereby increased. Recent large installations, of which that at Detroit is typical, commonly include mechanical screens, with $\frac{1}{8}$- to $\frac{1}{2}$-in. openings, in addition to the coarse racks or other devices used primarily for pump protection. The screens are usually cleaned by water jets; where needle ice is encountered, the use of steam jets, as at St. Paul, is of advantage.

Stationary screens, made up of wire mesh, are sometimes installed at the outlet of the coagulation basins to keep leaves and other floating material out of the filters. Their care involves some labor, but it is amply justified by the appearance of the water on the filters.

Aeration—The usefulness of aeration has been enhanced by a number of recent studies by F. E. Hale at Brooklyn and John R. Baylis at Chicago, which have brought out its limitations and tended to fix its place in the water-purification picture. While somewhat discredited as a method of taste-and-odor removal, benefits in reoxygenation and removal of gases have been proved. Sprays seem to fulfill the conditions requisite for rapid absorption of oxygen and dissipation of carbon dioxide better than other forms of aerators, but many types are in use. Compressed air is used with good results at St. Paul, Minn., Tulsa, Okla., and Neodesha, Kan. Special equipment for mixing air and water has been developed and has been used with apparent success in several instances.

Aeration immediately following the addition of coagulant, and before the floc is formed, seems to beneficial, particularly when iron salts are used. In iron and manganese removal, in softening and in the correction of corrosive conditions, aeration is beneficial to the extent that carbon dioxide is removed and the pH is increased, but lime treatment is generally required to complete the process. Aeration is a useful tool, but its successful use depends on a full realization of its limitations.

Grit Removal—The basin trouble incident to the removal of sand and coarse silt have been largely overcome by the development of equipment for the concentration and continuous removal of sludge. L. A. Day, in the *Journal*, A.W.W.A. April, 1929, states that at times as much as 42 tons of mud per million gallons must be removed from Missouri River water at St. Louis. George F. Gilkison, in the 1930 report of the fire and water commissioners, gives the following figures for one year's operation at Kansas City:

Treatment Unit	Tons of Sediment Removed per Year	Tons Per M.G.	Per Cent of Total
Pre-sedimentation basins (4 hours)	159,626	8.1	85.06
Settling or preliminary coagulating basins (9 hours)	24,060	1.22	12.81
Final coagulation basins (3½ hours)	2,187	0.11	1.16
Filters	1,811	0.092	0.97

A view of the equipment in one of the four pre-sedimentation basins at Kansas City, Mo., is shown in Fig. 1, and the condition that grit removal is intended to prevent is shown in Fig. 2. The latter is a photograph of one of the old Kansas City basins drawn down for cleaning after an operation period of only 30 days.

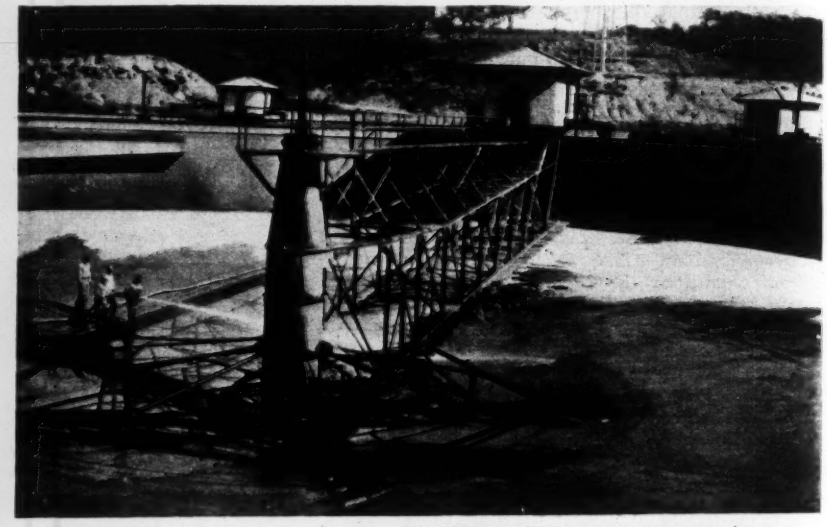


Fig. 1—Mud-removal apparatus in pre-sedimentation basin at Kansas City, Mo., water plant.

Algae Control—Copper sulphate treatment still seems to be the most useful method of controlling the growth of algae and micro-organisms in lakes and reservoirs, but the effects of this life, in the treatment plant, as shown by foul-smelling basin sludge, badly smelling and tasting water and dirty filter sand, can best be controlled now by the use of chlorine with or without ammonia, or by activated carbon or by some suitable combination of these chemicals. Aeration is helpful in some instances.

Pre-Chlorination — The status of chlorination has advanced from that of a mere "factor of safety" to that of

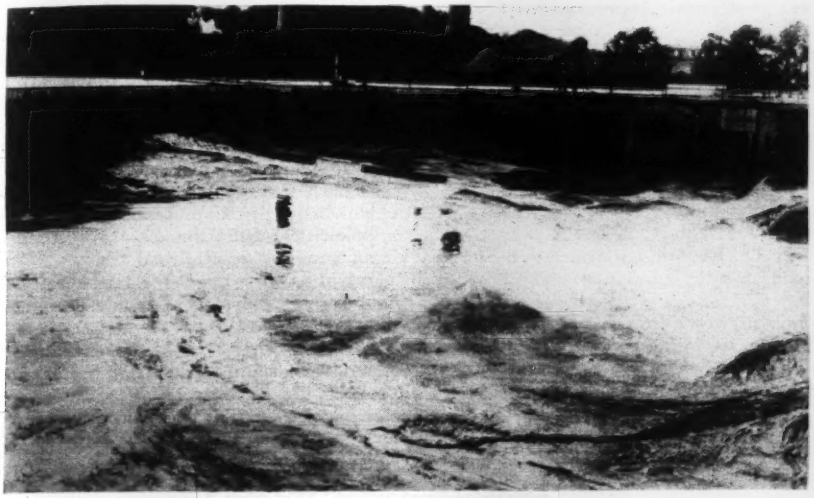


Fig. 2—Accumulation of mud after 30 days' operation in one of the old Kansas City basins.

"an integral part of water treatment," and its use in preliminary treatment has become almost, if not quite, as general as its application to filtered water for the sole purpose of sterilization.

Many supplies, too highly contaminated for safe use with coagulation, sedimentation and filtration, are now being used, and this is made possible through the reduction of bacterial load by pre-chlorination. In cases of extreme contamination superchlorination may be employed, and the oxidizing as well as the sterilizing effect of chlorine is brought into play. Numerous operators report beneficial effects from maintaining chlorine residuals throughout the treatment cycle. At Glencoe, Ill., where superchlorination is practiced and a residual of 0.5 p.p.m. is maintained in the clear-water reservoir, sodium bisulfite is used to dechlorinate the effluent to a point where tastes are not noticeable. Activated carbon is successfully used for this purpose in a number of plants.

Coagulation and mixing

Coagulation—The basic principles of coagulation have been greatly clarified by experience and research work, and while no really new coagulants have been introduced, a vast improvement in the quality of chemicals and dosing equipment has been made. The existence of an "indifferent pH range" for coagulation is now recognized, and pH control is widely practiced.

Messrs. Bartow, Black and Sansbury (*Civil Engineering,* March, 1933, p. 171) place this range for ferric salts between pH 6.5 and 8.5. At Providence, R. I., it was found advisable to raise the pH to 9.3 with lime to get good coagulation, insure the removal of manganese and produce a non-corrosive water. Optimum pH values seem to vary quite widely and probably must be established by trial in individual cases.

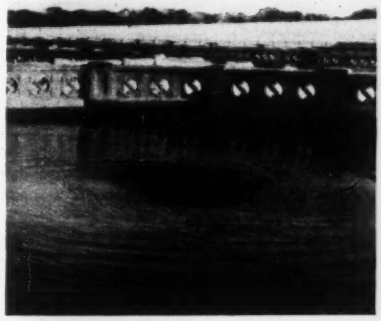
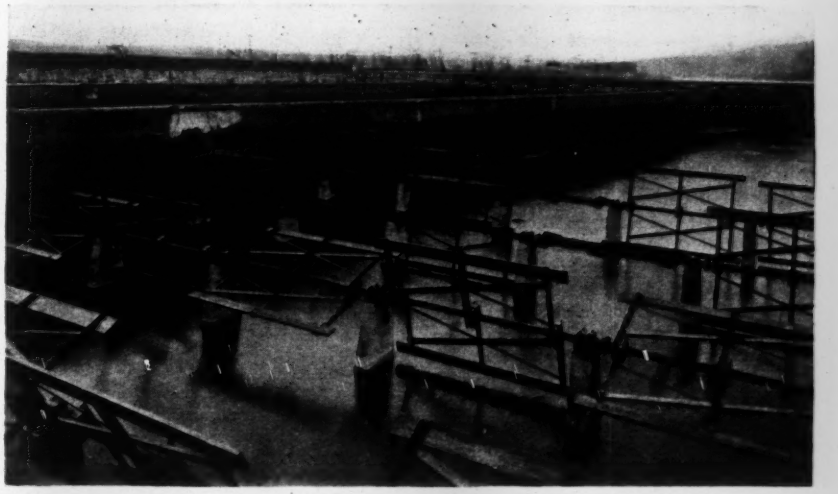


Fig. 3—Spiral-flow mixing tank at Tulsa, showing central vortex before correction by placing vane transversely over outlet.

Chemicals for coagulation are now generally available in suitable form for use and, where possible, dry feeding seems to be preferred. For corrosive chemicals such as ferric chloride, several ingenious solution feeders made of non-corrosive materials are available.

Fig. 4—Flocculating device developed at Richmond, Va., consists of horizontal paddle wheels set transversely at the inlet end of the coagulation basin.



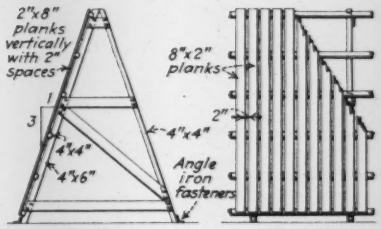
Several new combinations of old forms of coagulants have been introduced, as for instance sodium aluminate, chlorinated-copperas, ferric sulphate and others. Ferric coagulants seem to be increasing in popularity, and the present low price of chlorine together with improved methods of handling it has made the home production of ferric chloride much more feasible than it was when introduced by Bull in 1898.

At a number of the larger plants it has been found economical to manufacture alum from bauxite and sulphuric acid. J. W. Armstrong (*Civil Engineering,* March, 1933, p. 168) has recently given a good description of the equipment and processes involved at the Baltimore installation, where the coagulant is handled in liquid form.

The handling and storage of chemicals have always been a considerable problem, and the equipment now available for unloading and conveying by means of air is a distinct advance. The recent installation at the Daleclaria plant at Washington, D. C., is typical.

Mixing—It is now realized that mixing is an essential to good coagulation and that a great deal depends on the velocity of mix. This is not a new discovery, since the effect of mixing was noted at least as early as 1915 (*Engineering Record,* Sept. 4, 1915, p. 292), and probably earlier, but its importance was not generally realized at that time. It is now recognized that violent agita-

Fig. 5—A frame-baffle with 2x8-in. planks spaced to leave 2-in. vertical slots placed across the inlet end of the Tulsa coagulating basins.



tion is advisable for a period long enough to insure a thorough mixing of the chemical with the water and that this should be followed by a longer period of movement at a relatively low velocity. There seems to be no definite means of determining the exact time of mixing required, but from 20 to 40 min. is allowed in many of the recent plants. Probably the gentle mixing should be continued until the chemical reactions are complete and the flocs have been built up to the required size. Temperature seems to affect the factor of time more than does the amount of coagulant. Cold waters require longer mixing periods than do warm waters.

Many types of mixing tanks and equipment have been developed, particularly for the initial violent agitation. Compressed air is successfully used in some plants. So long as the chemical is thoroughly diffused throughout the total volume of water, the method does not seem to be important. For the longer and gentler agitation mechanical agitators are probably advisable, since they permit some flexibility, but in many plants baffled basins serve the purpose. Spiral-flow circular tanks have proved satisfactory at Sacramento, Calif. (both old and new plants); Kansas City, Mo.; Tulsa, Okla.; and at the Howard Bend plant at St. Louis, Mo. The installation at Tulsa is shown in Fig. 3. The principal trouble with this type of tank arises from the formation of a vortex immediately over the outlet. Resulting velocities are higher than desired at this point, causing an increased loss of head and a tendency to break up the floc. The vortex trouble at Tulsa has been corrected by the insertion of a vertical steel vane transversely over the outlet.

A recent and interesting development along this line is the invention of the "flocculator" by M. C. Smith, of Richmond, Va. This equipment consists of a series of horizontal paddle wheels set transversely in the coagulating basin. Slow movement of these paddles tends to keep the water in motion and to circulate some of the formed floc.

Sedimentation

Settling Basins—Recent settling-basin design has shown a definite trend toward the reduction of inlet and outlet velocities and the elimination of eddy currents and dead spaces. Observations with a glass model tank and in a plant basin at Massillon, Ohio, led F. P. Larmon to these general conclusions:

1. Entrance velocity must be reduced and distributed over the entire end area of the basin.
2. Jets, eddy currents or change in velocity must be avoided.
3. Outlets should be of the skimming type, extend over the entire end of the basin and, if possible, a short distance into basin.
4. Over-and-under or around-the-end baffles help but do not give full efficiency due to changes in velocity.

A very successful method of equalizing velocities, distributing flow and eliminating dead spaces is the insertion of a transverse baffle made of slats, as shown in Fig. 4. This is a wooden A-frame with 2x8-in. planks spaced to give 2-in. vertical slots. The frames were placed 45 ft. from the inlet ends of the two 105x156-ft. coagulating basins at Tulsa.

Some of the recently constructed settling basins are equipped with mechanism for sludge removal, as at Cedar Rapids, Ia., and Youngstown, Ohio. The latter plant has a high degree of flexibility, with its four 800,000-gal., 95-ft. square units (*ENR*, March 30, 1933, p. 395). In the majority of cases, however, floors are designed for hose flushing. Several have mud valves located at intervals of 30 to 50 ft., for the purpose of reducing the amount of hosing required.

Reclamation of Sewage—The reclamation of sewage is not usually considered under the head of preliminary water treatment, but it has been demonstrated at Los Angeles (*ENR*, March 12, 1931, p. 883 and Oct. 29, 1931, p. 683) that a combination of sewage treatment, sterilization and water treatment results in a perfectly acceptable drinking water.

At the Grand Canyon National Park reclaimed sewage is used for practically all purposes other than domestic consumption, and the construction contracts have been awarded for a sewage-disposal plant of the activated-sludge type at Herington, Kan., the effluent of which is to be softened and sold as boiler water to the Chicago, Rock Island and Pacific Railroad Co.

The idea of sewage reclamation for domestic use is of course repulsive, but, after all, sewage is 99.98+ per cent water. For many uses the bacterial content is not important, and in many instances the reclamation of sewage is economically feasible and safe from a public-health standpoint.

The field of preliminary treatment is a broad one, and while there is still room for improvement the progress made in the past decade is well worthy of praise. Probably the greatest present need is a more general application of the methods, equipment and chemicals now available, together with a proper investigation of the particular water to be treated before design is actually made.

A Decade of Advance in Knowledge of Filtration

Sand-bed behavior, during both filtration and washing, has been studied intensively—Proper sand size is still a disputed point—Perforated-pipe underdrains are extensively used

By J. W. Ellms
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A CONSIDERABLE amount of investigation has been carried on during the past ten years on the chemistry and physics connected with the process of filtering water to be used as a public supply. The problems involved in this process naturally divide themselves into the proper conditioning of the water applied to the filter, the action of the filtering medium in the clarification of the water and the most effective method of cleaning the filter bed. In this article only rapid gravity filters to which coagulated waters have been applied will be discussed.

A knowledge of the physical and chemical characteristics of natural waters that are to be treated with a chemical coagulant and then filtered is necessary for the proper conditioning of the water to be applied to the filters. The dissolved mineral constitutents of natural waters vary widely. For the formation of the chemical coagulant an adequate alkalinity is necessary; for the most complete precipitation of the chemical used, there is an optimum zone of hydrogen-ion concentration required; for the removal of vegetable coloring matter, slightly acid conditions are productive of the best results, while on the other hand slightly alkaline conditions are more favorable for the precipitation of suspended clay particles.

One of the interesting attempts at adjustment of the applied water was made by Baylis (*Journal*, A.W.W.A., May, 1923) at Baltimore in which the lowering of the pH value of the raw water by the addition of sulphuric acid was tried. The increased hydrogen-ion concentration that was produced was in this case favorable to the more complete precipitation of the aluminum hydroxide and to the removal of vegetable coloring matter. On the other hand, Catlett (*Journal*, A.W.W.A., July, 1924) found that all attempts were unsuccessful to cut down the pH of highly colored waters with sulphuric acid and thus reduce the amount of alum required.

With raw waters having pH values of

7.0 or less, reduction of these values for the purpose of better floc formation may be justifiable; but where the pH of raw water is 8.0 or above, experience with Lake Erie water has indicated that it is not a practicable measure. (1st & 2d Annual Report, Ohio Conference on Water Purification.) The investigations of Clark, Theriault (U. S. Public Health Service Report, Feb. 2, 1923), Miller and Hatfield (*Journal*, A.W.W.A., November, 1925) have shown that there may be one or more zones of hydrogen-ion concentration in which the most complete precipitation of the hydroxides of aluminum and iron is produced. The practical application of the principles developed by these workers has not as yet found its way into general use.

Filter-bed studies

Probably more work has been done in studying the action of the filter bed during the process of filtration and its periodic cleaning than on any other part of the filter. The structure of the filter bed has been varied from time to time with the hope that better results would be obtained. The fashion in the proper size of filter sand swings from coarse to fine and from fine to coarse without much real evidence to substantiate a claim for the change. The employment of graded gravel layers to support the sand bed has been quite generally adopted because of easy installation and low cost. Various patented bottoms as a substitute for a part of the lowest layers of gravel have not as a rule met with much approval.

The gradation of the sizes and depths of the several gravel layers has been quite varied. Experience, however, has shown the necessity for careful selection of the various sizes in the different layers and for their proper depths. The gravel layer serves as a distributor of the washwater in the cleaning process and as a support for the sand layer.

As a distributor of the rising washwater, it is well adapted to this purpose, provided the layers are uniformly graded so that the finer sizes do not penetrate the next coarser layer below them and are of enough depth so that they are not disturbed by the upward rush of the washwater. The loss of head through such layers of gravel is low and of no especial significance either in the filtering or washing process.

The gravel layers as a support for the sand bed should be fine enough at the plane of contact with the sand to prevent the latter sifting down through the fine gravel. This requirement is perhaps the most difficult one to meet and may be impossible of accomplishment. However, by a proper selection of the depth and sizes of the finer gravel layers, penetration of the sand may be reduced to a minimum.

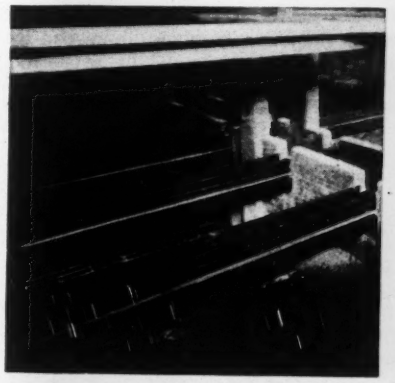
To prevent the penetration of the sand into the fine gravel layer, a mixture of the gravel with cement in the ratio of 1 part of cement to 9 parts of gravel was suggested by Jenks (*Journal*, A.W.W.A., November, 1926). It was proposed that this lean gravel mortar slab be made about 8 in. thick. The passage of the water through this slab would doubtless produce some loss of head, and if of approximately uniform composition, the rising washwater would be evenly distributed at the bottom of the sand bed. Solution of the cement and the ultimate disintegration of the slab appears to be the chief objection to this type of construction. This suspected difficulty was found to develop in the few cases in which it has been tried.

Part of the operating floor of the Baldwin filter plant at Cleveland, Ohio.

Size of filter sand

The most effective size for the sand has been and still is a fruitful source of controversy. The work of the Am.Soc. C.E. committee on filtering materials, which is being conducted with the assistance of the water-filtration plants of a number of the large cities in the United States, has attacked this problem, and it is hoped as a result that certain fundamental principles may eventually be established.

For convenience, we may classify filter sands below 0.45 mm. in diameter as fine sands, and above this size as coarse sands. In filtration the penetration of the suspended matter into fine sand is limited to within 3 or 4 in. of the surface. As the average size of the individual particles increases the penetration of the suspended matter into the bed becomes greater. Provided the depth of the bed is sufficient to effect clarification, this penetration is of no consequence so far as filtration is concerned. However, the difficulty of removing the suspended material strained out of the water sets a limit to the depth to which it should be permitted to go. Consequently, the size of the sand particles selected for a filter bed must be such that both the requirements of complete clarification of the water, and the effective cleansing of the sand bed are met.



Interior of a 4-m.g.d. rapid sand filter, showing part of the manifold and laterals of the strainer system and the washwater gutters.

The hydraulics of rapid sand filters have been quite recently studied by Hulbert and Feben (*Journal*, A.W.W.A., January 1933, and *ENR*, Dec. 1, 1932, p. 647). In their research they dealt with the factors of sand size, depth, porosity, rate of flow and temperature, and the inter-relation between these variables has been set up in a formula. This important study is a start toward furnishing a logical basis for design in place of "accepted practice." The problem is complex and needs further elucidation, especially as this investigation was made entirely with clean sand. How these hydraulic factors are modified by the progressive deposition of sediment in the actual process of filtration is yet to be demonstrated.

Although sand is the generally used filtering medium, coal has been used in a few plants for a number of years. Recent investigations by Turner and Scott (*Water Works and Sewerage*, February, 1933) have shown that anthracite coal properly sized furnishes an excellent medium for filtering water. Its low specific gravity, which permits low washwater velocities and still pro-

duces adequate expansion of the filter bed, and the shape of the particles, which differs from that of the ordinary sand grain, offer possible advantages that may be of value in many filter-plant installations.

Filter washing

The cleaning of the filtering medium is one of the oldest of filtration problems. Its efficiency is a measure of filter-plant performance. Its intimate relation to underdrain design and to the structure of the filter bed needs no elaboration. With fine sands the tendency of the sediment to mat at the surface is well known and produces a difficulty in washing that is not easy to overcome. Marshall (Ohio Conference on Water Purification, Annual Report, 1932) has shown, in working with glass-tube filters, that this matting effect decreases as the sand at the surface is made coarser, and that the washing out of the sediment is somewhat less difficult. With the coarsest sands, however, the penetration of the sediment is so great that a high velocity of the wash water is required to move the coarse grains in order to remove the sediment, and this velocity is far in excess of what is practicable. These effects naturally force a compromise in the size of the sand grains in the surface layer in order that too high velocities of the washwater are not required.

It was further found that by mechanically breaking up the surface mat formed on the fine sand layers, the washing out of this material was much better effected and the volume and velocity of the washwater needed was greatly reduced. The old circular-tank filters, which used rakes for stirring the sand at the same time the washwater at low velocity was forced up through the bed, undoubtedly aided in cleansing the bed. The use of air also may have some effect in breaking up the surface mat. The high-velocity method of washing, developed by the writer and quite generally adopted, displaced these older methods, but has introduced new difficulties which must now be overcome. It would seem as though this may be accomplished by so fixing the sizes of the sand grains in the surface layer that too dense a deposit of sediment is avoided, and too high velocities of wash-water are not required to move it.

The work of Hulbert and Herring (*Journal*, A.W.W.A., November, 1929, and *ENR*, Oct. 31, 1929, p. 696) on the washing of rapid filters was a distinct contribution to the art. From their work at Detroit they showed that the variation in temperature of the washwater changes its viscosity to such an extent that the expansion of the sand bed at the lower temperatures is much greater than it is with the warmer water for the same velocity of rise. They concluded that the expansion is independent of the freeboard or lift above the sand, and that it depends for its value upon the rate of flow of the washwater, the temperature of the water and upon the size of the sand grains. As the rate of wash increases, the expansion of the sand bed increases, and as the temperature of the washwater and the size of the sand grains increase, the expansion of the bed decreases. These variables have been incorporated in a formula.

In later investigations by Wallace, Hulbert and Feben (*Journal*, A.W.W.A., June, 1931) the subject of filter-sand shrinkage was thoroughly studied, with the result that the growth of side-wall cracks and other cracks in the sand bed, as well as the formation of mud shelves along the side walls, was attributed to a volumetric contraction taking place due to the decrease in the voids and a compacting of the bed. This causes, according to these investigators, a reduction of the total surface area. They conceive of this phenomenon as the result of hydraulic conditions set up by the passage of the water through the sand bed at unequal velocities and pressures. When the effluent valve of a filter is closed, the sand on the vertical sides of these cracks tends to drop back into the opening as the sand seeks its normal angle of repose. In this way repetitions of this action will tend to carry dirty sand down to lower levels and will form more dense zones through which the washwater will find it difficult to pass. Although there may be some differences of opinion as to some of the details in the hydraulics of this phenomenon as described by these investigators, in the main their opinions seem to be correct. Certainly their explanations seem more rational than those which were put forward earlier during the past decade.

The complete cleaning of a sand bed at each washing period is undoubtedly a condition that is highly desirable, but it is questionable, in the writer's opinion, whether this is possible. It seems inevitable that the longer a filter is operated the greater the accumulation of sediment within the bed will be, and that the better they are washed at each period the longer it will take before the accumulated deposits become troublesome. There is no doubt that the rate of accumulation is much diminished by adjusting the percentage of expansion of the sand filter bed by correlating the rate of rise of the washwater with its viscosity and the size of the sand grains.

Underdrain system

The underdrain system of a filter is one of its most important parts, since it serves two purposes: to draw the water evenly from all parts of the bed during filtration and to discharge uniformly the water used in washing the filter. The designers of the numerous underdrain systems that have been built seem to have had a pretty clear conception of what was required, but have not always been able to produce the desired result. One of the first difficulties encountered was to keep the filter sand out of the perforated or slotted strainer nozzles when the sand was placed directly on the underdrain system without any intervening layer of gravel. It soon became evident that a gravel layer afforded a certain degree of protection to the nozzles and was generally adopted.

As filters became larger, extensions of the distributing piping over the whole area of the bottom of the filter tank became necessary and resulted in manifolds with branching piping systems into which were screwed the strainer nozzles. One of the earliest designs employed consisted of a perforated-pipe system, the perforated laterals being connected to a manifold. This system is still extensively used, and when properly designed provides an underdrain layout that may be adapted to almost any size of filter.

Almost all underdrain systems are able to meet the conditions imposed by the downward filtration of the water through the bed. The difficulty arises when they are employed to cleanse the bed by forcing washwater through the underdrains and up through the bed at rates from 8 to 12 times the rate of filtration. The hydraulics of a perforated pipe system have been carefully studied by Jenks (Report to city of Sacramento, 1920), who determined the relation between the size of the laterals and their length to the area of openings of the perforations. The writer (*Journal*, A.W.W.A., December, 1927) extended this study to the relations between the size and length of a manifold to the size and length of the laterals and to the area of openings of the perforations.

In units having an area of sand surface of 1,000 to 1,500 sq.ft., it has been customary to provide a center manifold in each half of the unit, and to place perforated laterals on each side extending to the walls. This has produced dead ends at each lateral into which sand, which may have sifted down through the gravel, could collect. It is believed that a better design could be provided by doing away with a single central gutter, splitting it into two gutters at the sides of the tank, extending the laterals across the full width of the filter and obtaining their supply of water for washing from the manifold placed under the main side gutters. This would do away with any dead ends in the laterals and would provide a more uniform washwater distribution.

The combined area of the perforations in underdrain systems has ranged from 0.2 to 0.4 per cent of the sand area. Armstrong conceived the idea of using a wooden grid bottom in place of the strainer nozzles or perforated pipe laterals, which would provide an area of opening from 20 to 50 per cent of the sand area, depending upon the spacing of the grid members. This radical departure from existing practice would seem to produce hydraulic instability, which might endanger the structure of

the filter bed during the inrush of washwater. Successful operation of this type of underdrain system has been reported, however, as well as failure. A deep gravel layer properly correlated as to sizes and depth with the area of opening between the grids, and with the uniform introduction of the washwater under the grids, may result in proper functioning.

There are still opportunities for improvements in the design, construction and operation of rapid filters; and although they have been relieved in part of the responsibility for producing effluents with high percentages of bacterial removal, nevertheless they will always be needed for clarification purposes.

Control of Odors Marks Progress in Sterilization

A brief account of the recent developments in chlorination technique and the methods that have come into use to prevent or remove objectionable tastes and odors

By George D. Norcom
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DURING the past ten years or so water-purification practice has been greatly aided by the striking developments in the field of sterilization and control of objectionable tastes and odors. Many water supplies are subject to taste and odor troubles which occur at the source and must be controlled by suitable treatment. Unfortunately, chlorination has frequently been responsible, sometimes on account of the formation of taste-and-odor-producing substances following the treatment, but perhaps more frequently on account of overtreatment, with the production of chlorinous taste and odor.

Of the various methods available for the sterilization of drinking water, chlorination is the most important. Other methods are boiling, ozone, permanganate, bromine, halazone and excess lime, all of which are applicable to special cases, but none of which are of general application. At present the use of chlorine is almost universal.

The trend of chlorination practice in recent years has consisted very largely in the development and perfection of the methods discovered or proposed by the pioneers in this field. The early work in Europe on the sterilization of sewage with hypochlorite (1889-1900) was soon followed in this country by the work of Woolf at Brewster, N. Y., Pratt and Kimberly at Camp Perry, and Phelps at Baltimore and Red Bank. Chlorination of a large water supply under scientific control was first successfully attempted in 1904-'05 at Lincoln, England, by Sir Alexander Houston and Dr. McGowan. The first important work on chlorination of water in the United States was that of George W. Fuller at Louisville in 1896. In 1908 Col. George A. Johnson carried out the first plant scale application of chlorine to water at Bubbly Creek, Chicago. In the same year (1908) Dr. Leal and Col. Johnson began the epoch-making venture of chlorinating the Jersey City water supply.

All of the early work in chlorination was done with solutions of the hyochlorites of calcium and sodium. The first practical use of liquid chlorine for the sterilization of water is credited to Major C. R. Darnall (1910). The first large-scale applications of the process were made at the Niagara Falls plant of the Western New York Water Co. (1912), and at Baltimore (1913). By 1913 control apparatus for applying liquid chlorine from cylinders had been introduced and there has since been a steady advance in the perfection of this type of equipment, which is based on the original patents of Darnall and Ornstein.

There has been little change in the process of simple chlorination since the first application of bleach to the Jersey City water by Leal and Johnson. Methods of chlorine application and control have been improved by the use of modern mechanical devices the substitution of liquid chlorine for bleach and a more complete understanding of the process. The old nascent oxygen hypothesis has been replaced by the theory of direct destruction of bacteria by the chlorine.

Wellington Donaldson has pointed out that the early uses of chlorine compounds for the sterilization of water were applied as prechlorination doses, ahead of the filters. Subsequently, a steady shift of the point of application of chlorine occurred until postchlorination, which is the application of chlorine to the filtered water, became the accepted practice. Reasons of economy seem to have been largely responsible for the shift. One of the important developments in the last decade has been the revival of prechlorination. This has been occasioned by the increasing pollution of sources of water supply, the establishment of more rigid standards of quality and the discovery of numerous important advantages to be secured by prechlorination. The following advantages are chosen from Donaldson's list as being well established:

1. Reduction of bacterial loading on filters, permitting better and more consistent over-all quality than is possible with effluent chlorination alone.
2. Increased factor of safety.
3. Better color removal (in certain instances).
4. Keeps sand beds cleaner and prolongs filter runs.
5. Control of plankton in basins and filters. Control of grosser biological growths.
6. Taste and odor elimination.

Postchlorination is standard practice at most filter plants. The more conservative sanitary officials prefer to consider postchlorination merely as a factor of safety and insist that the filter effluent should conform practically to the Treasury standard for drinking water. The simplicity and economy of the prechlorination process have made it possible for many plants to conform to the above requirement that could not otherwise have done so except at great expense. This explains in part the popularity of prechlorination as an adjunct to postchlorination.

Superchlorination and dechlorination on a plant scale have been employed in relatively few instances. Probably the only large plant using this process as a routine is Toronto, where Howard reports excellent results, not only from a bacteriological standpoint but also for taste and odor control. The process has also been tried in emergencies where the raw water became intensely polluted with organic matter.

In view of the almost universal popularity of chlorine treatment, it would be well to mention briefly some of the limitations of the process. In the presence of phenol or certain other industrial wastes, the use of chlorine is attended with the possibility of unpleasant taste and odor. To be effective, chlorination must be adequate and continuous. This means that, in cases of fluctuating chlorine demand, frequent residual-chlorine tests are essential. Apparatus for the recording of residual and the automatic adjustment of dosage has been developed, but such equipment is both complicated and expensive, so that the majority of chlorination plants will probably continue to use manual control for a long time to come. The ortho-tolodine test for residual chlorine has proved very satisfactory and is in almost universal use. In the presence of interfering substances, especially manganese, precautions must be taken to assure the presence of residual. Another limitation of the ortho-tolodine test may be encountered when the water that

is being chlorinated contains undue amounts of nitrogenous organic matter. In this case all of the chlorine may combine with the organic matter to form a complex chlorine addition product, which has very weak, if any, sterilizing power. As a result, sterilization may be ineffective, even though a strong positive residual chlorine test is secured with ortho-tolodine, due to the liberation of free chlorine by the acid of the reagent. The sterilizing action of chlorine is adversely affected by the presence of excessive color, turbidity or organic matter.

Probably the most important development in the sterilization of water supplies that has occurred during the last decade has been the revival of the use of ammonia with chlorine in what is known as the chloramine process. Recognition of the germicidal value of chloramine is attributed to S. Rideal (1910), although the first important experiments with this compound in water treatment were made by Race at Ottawa in 1915. Later the process was used at Denver, Colo. and St. Joseph, Mo. (1917). The process did not attain wide popularity at first, and the next important application of it appears to have been made by McAmis at Greenville, Tenn. (1926) in connection with the control of unpleasant taste and odor. Important research into this process has been made by Berliner, by Baker and Schmelkes, by Houston, Harold and Adams in England, Braidech at Cleveland, Spaulding at Springfield, Ill., and within the last few years it may be said to have taken the country by storm. First proposed as an adjunct to chlorination, where unpleasant taste and odor were produced by chlorine alone, important additional properties were soon recognized. Among the benefits ascribed to this process by Braidech, the following have been selected as most important:

1. The prevention of phenol and chlorinous taste and odor.
2. The ability to carry a high residual chlorine without accompanying taste and odor.
3. Persistent sterilizing action continuing for long periods, thus carrying residual chlorine throughout storage reservoirs and distribution systems.
4. Low cost of equipment and supervision.

The ammonia-chlorine process has limitations. There is doubtless an upper limit to the amount of phenol or allied substances to be allowed in the raw water, beyond which the ammonia-chlorine process cannot be expected to produce odorless and tasteless water. It has been shown by Holwerda, Schmelkes, Gerstein and others that there is a pronounced lag in sterilizing action when this process is used, as compared to chlorine alone. Consequently, there should always be a sufficient contact period provided to insure complete sterilization before the water is delivered to the consumers. The required time is usually stated as two hours or more. It has also been shown by Baker and Schmelkes that at high pH sterilization with ammonia-chlorine is much slower than with chlorine. This factor should receive consideration in plants where the pH of the water is raised to inhibit corrosion. When using the ammonia-chlorine process, it is important that each substance be thoroughly mixed with the water before the other is added, and that the period of time between the additions should be relatively short. As pointed out by Orchard, the order of adding these substances to the water is unimportant as far as sterilization goes, but for phenol taste control the ammonia should be added first. There is also considerable latitude in the ratios applied. These vary from the theoretical 1 NH_3 to 4 Cl; up to 2 NH_3 to 1 Cl., which has been suggested in aggravated cases of phenol pollution. It should be remembered that the more ammonia applied in relation to chlorine the slower will be the sterilization process.

It has been said that the greatest advance in the treatment of public water supplies during the past few years has been in the field of taste and odor control. Certainly this subject has received a major part of the attention of waterworks operators. The public has become increasingly conscious of the aesthetics of drinking water, and a clear colorless supply—free from taste or odor—is now being demanded in all parts of the country. The industrial expansion of the last 30 years and the continuous increase of population has added greatly to the pollution of sources of water supply, and taste and odor problems have been very much intensified.

The most important of the older methods of taste and odor prevention are copper sulphate treatment, aeration and sand filtration. These still remain among the most effective methods. Copper sulphate is considered in the nature of a specific for the destruction of plankton, which are responsible for many of the tastes and odors in impounded water supplies. Chlorine is also used in this connection. Aeration is very important in removing dissolved gases and odoriferous substances volatile at outdoor temperatures. The late Allen Hazen was always strong in his praise of slow sand filtration for the removal of taste and odor. Coagulation and rapid sand filtration are also very effective. These methods were quite satisfactory in dealing with many of the taste and odor problems of the past, but they were not adequate in all cases.

During the past decade a number of important developments have taken place in the field of taste and odor prevention. These may be classified as special treatments applied at the plant. In practically all cases they involve the use of filtration. Among the first chemical substances to be used, in an attempt to combat phenol tastes, was potassium permanganate, by Jas. M. Caird, at certain Great Lakes plants. Although this treatment for phenol taste has been largely superseded by other methods, it is still valuable as an aid in satisfying oxygen demand when used in conjunction with chlorine. Other methods for taste and odor control, involving the use of chlorine, include ammonia-chlorine, prechlorination, super and dechlorination, all of which have been discussed. It is important to note that prechlorination, with or without ammonia, has become a leading factor in taste and odor control.

It is only about five years ago that John R. Baylis conceived the idea of using activated carbon for taste and odor removal on a large scale. Carbon was once very popular with filter manufacturers in England, and its use had been largely confined to small installations. Just prior to and during the World War there had been developed some very active carbons, and Baylis tried many of these in filters. The ability of some of these carbons to remove taste and odor from water was little short of amazing. They also had the ability to remove completely large quantities of residual chlorine without imparting any taste or odor to the water. This suggested an ideal arrangement for super and dechlorination. Following the first work by Baylis, numerous experiments with this process were made in various parts of the country and they were almost all successful. The widest range of taste and odor could be handled with ease. The idea has failed of rapid development for several reasons: (1) the limited quantity and high cost of an efficient granular carbon, suitable for use as a filter medium; (2) the cost of making the installation; (3) the introduction of powdered activated carbon. The only large-scale installations of secondary filtration through granular carbon which have come to the writer's attention are at Seneca Falls, N. Y., and Bay City, Mich.

Shortly after Baylis began his experiments on filtration through carbon, a powdered activated carbon was placed on the market. This substance was relatively inexpensive and could be applied to the water undergoing treatment in the same manner as any other chemical substance. It was found that this simple and easy method was very effective in removing taste and odor from water. Since that time powdered activated carbon has come into general use and is probably the most effective simple remedy for taste and odor trouble now available. Moreover, it is possible to apply this carbon in such a way as to coat the sand surface of the filter, thus securing a moderate amount of dechlorination if desired.

Fuller's Earth, or bleaching clay, is another finely divided substance, possessed of adsorptive properties, which has been proposed for taste and odor removal. This substance is particularly valuable as an aid to floc formation, and it has helped in taste and odor removal where the trouble is due to waste oil.

The wateworks operator of today has at hand not only an improved knowledge of the process of water purification but also new and valuable methods of sterilization and odor control.

Water-Softening Practice Shows Rapid Growth

Education of the public and improvements in softening processes encourage move toward removal of dissolved minerals —Recarbonation is the outstanding technical development

By Charles H. Spaulding
Superintendent of Water Purification, Springfield, Ill.

THE DECADE beginning in 1923 has witnessed a broad movement toward municipal water softening in the United States. The few scattered plants pioneering in the first 23 years of the twentieth century have been joined by many others. C. P. Hoover supplied a list of 110 cities and villages in 1929 that were softening their municipal supplies, and additional plants numbering at least 49 have been added since that date. According to records made available by the engineering division of the Illinois State Department of Public Health, 75 of the 136 purification plants installed in the United States since 1929 have been softening or iron-removal plants.

It is possible that education of the public to the advantage of soft water has had something to do with this movement toward softening. The claims of the soap economists have most certainly gained ground during this period. A glance at the statistics of soap production and consumption in the United States makes it easy to appreciate that more money is spent for soap than for water in some hard-water communities. The balance either way depends upon the water rates and soap prices in any case; but in general they are of the same order of magnitude.

Recarbonation

Improvements in softening processes also have opened the way to more general adoption of municipal water softening, a number of important advances playing their parts. The most important of these improvements is recarbonation, which makes it possible to prevent or control scale formation due to after-precipitation.

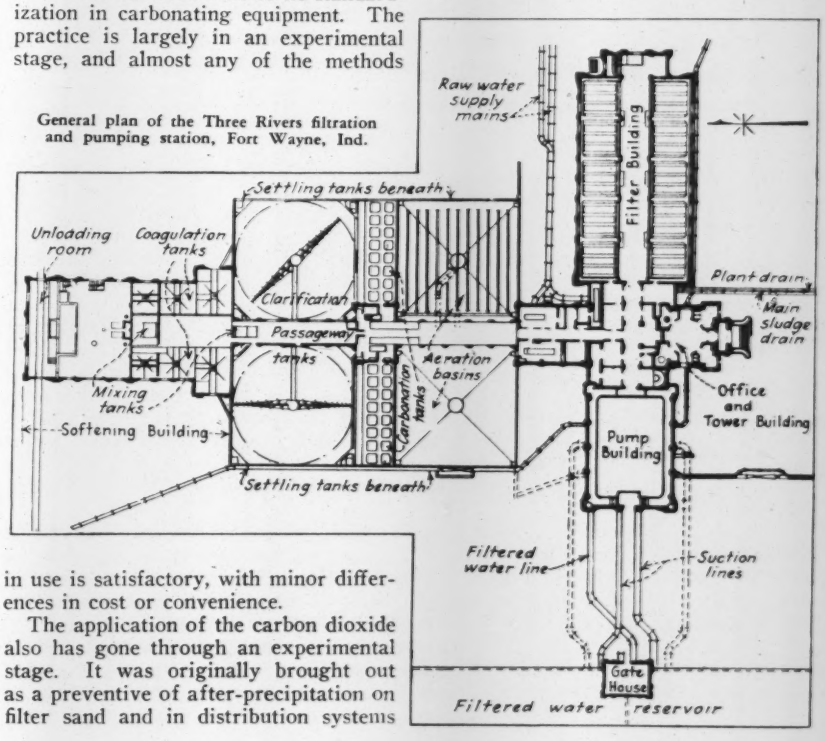
The diversity of methods of producing and applying carbon dioxide is striking. The fuels used are coal, coke, oil, gas and producer gas. Stack gas from power-plant boilers is being used in some cases, whether the fuel is coal, oil or gas. On the other hand, while the carbon dioxide is a byproduct of boiler operation, the idea of using both the energy as well as the gas produced by the fuel can be, and is being, accomplished by making the production of the gas the primary object, and by utilization of the heat as a byproduct either to drive the gas compressor or to heat water or part of a building. The economy of such combinations is important only on installations of several million gallons capacity or more. The fuel cost in a small plant is insignificant, but the ability to start, stop and control the gas is most important.

A survey of the whole field shows that there has been little or no standardization in carbonating equipment. The practice is largely in an experimental stage, and almost any of the methods in use is satisfactory, with minor differences in cost or convenience.

The application of the carbon dioxide also has gone through an experimental stage. It was originally brought out as a preventive of after-precipitation on filter sand and in distribution systems and meters; but it has found, in addition, a reverse application in producing a precipitate of calcium carbonate following excess-lime treatment ahead of filtration. With recarbonation it is possible to force the softening reactions, yet regulate the pH of the water leaving the plant to any desired degree of stability.

Next to recarbonation, mechanical removal of sludge from settling basins has had a most important effect on water-softening practice in the lime-soda field. It has simplified operation and probably halved the necessary size of basins. Today lime-soda plants are regularly designed with mechanical sludge removal and frequently with four-hour basins.

Perhaps not all credit for decreased basin requirements should be given to continuous sludge removal. Better understanding of mixing and coagulation has played a part. Long-continued stirring is a common device to produce fast-settling precipitates in the chemical laboratory. It works equally well in the plant, as engineers have learned. In order to secure this long-period stirring for all the water without the short-circuiting likely to occur in mechanically agitated mixing tanks, some of the best designs employ several mixing tanks in series. This was done, for example, at Findlay, Ohio, and more recently at Fort Wayne, Ind. In the Fort Wayne plant an additional refinement is incorporated. Here the first stage of mixing occupies about 2 min. at nominal plant rating. The next three stages, called coagulation, retain the water for 10, 14 and 21 min. respectively. The stirring in each tank is progressively slower,



General plan of the Three Rivers filtration and pumping station, Fort Wayne, Ind.

the purpose being to build up an ideal floc for settling.

The handling of quicklime has been radically improved during this decade. Beginning with the unloading operation, which was formerly painful and somewhat dangerous if quicklime or even hydrate was used, the substitution of vacuum unloaders has removed the dust and disposed of discomfort. Slakers too have shown great improvement. Dust is effectively removed. In the best modern installation, slaking is a continuous process requiring little more attention than feeding any other chemical. Dry feeders, except large weighing machines, were not considered as adapted to quicklime ten years ago, but today they are in common use.

Zeolite softening

Zeolite softening of municipal supplies is a development of recent years. In fact, every municipal zeolite plant known to the writer has been installed since 1920. Nevertheless, there were 28 listed by Appelbaum in 1932, and the list is growing. It is usually easy to show that the salt required for regeneration of zeolite is cheaper than the equivalent soda-ash. However, in dealing with lime softening for carbonate hardness, zeolite is at a disadvantage at the start, since lime is usually cheaper than the equivalent salt. Furthermore, the softening reaction with lime removes the lime added as well as the hardness, leaving the water lower in dissolved solids. Moreover, lime has considerable coagulant value, and lime-softening plants are usually efficient in removal of bacteria. Finally, the control of pH goes hand in hand with lime treatment. There are frequent cases, however, where zeolite has been adopted for both carbonate and non-carbonate softening of well supplies into which other purification problems do not enter and where coagulating basins and clarifiers are accordingly unnecessary.

A review of the municipal zeolite plants in the United States shows that surface supplies are rarely handled by this method. The method is particularly well adapted to small well systems; and for the most part zeolite installations have been confined to this class, which is, however, a very important class, perhaps the most numerous of any.

Iron removal

In iron removal, aeration continues to hold an important place. The two prerequisites of iron precipitation are pH elevation and oxygen. Removal of CO_2 by aeration and the consequent elevation of pH is the most essential consideration because water can hardly be handled in open tanks without the introduction of the necessary small amount of oxygen. It is probable that removal of iron has been responsible for the consideration given to water softening in many cases. The red-water problem is most intolerable in a domestic water supply; and because its solution involves a major capital investment no matter what the method of attack, it is an opening wedge for complete chemical treatment for softening as well as deferrization. There are doubtless many water-softening plants that are also iron-removal plants; but in most of these plants the iron is forgotten because its removal is complete and unavoidable. There are, of course, many soft waters containing iron, and in this field aeration still holds sway. Of 68 plants classed as iron removal only and installed in the last ten years, 54 are aeration plants, eleven are employing lime, two zeolite, and one chlorine. An outstanding example of iron removal by aeration in the case of soft water is the plant at Memphis, Tenn., which has just been duplicated.

New "Standard Methods" Shows Growth of Science

A brief commentary on the seventh edition of "Standard Methods for the Examination of Water and Sewage," contrasting it with former editions and tracing the scientific developments embodied in its text

By Harry E. Jordan
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A LITTLE LESS than forty years ago, the first steps were taken which led to the publication of the first edition of "Standard Methods for the Examination of Water and Sewage." Just a few weeks ago there was published the seventh edition of this important laboratory manual. A good appreciation of the developments that have taken place in water chemistry and bacteriology during the intervening years can be gained from the contrast between the two volumes.

The writer has recently been privileged to study some old scrapbooks from the files of Geo. W. Fuller, who was chairman of the group that edited the first edition. The names of Thomas M. Drown, William T. Sedgwick, Henry Leffmann, A. C. Abbott and many other early leaders in laboratory work are signed to a series of letters that exchanged viewpoints concerning the then very infant art of water bacteriology. On July 19, 1894, Dr. Adami, of Montreal, addressed a letter to nine men then prominent in the field advocating that a "combined investigation" be made "to remedy this present unsatisfactory state of bacteriological investigations of water." Dr. Adami was at that time the chairman of the subcommittee on methods of the committee on water supplies of the American Public Health Association. Major Charles Smart, of the Surgeon-General's office, was chairman of the latter committee.

After several preliminary outlines of the project had been made, a conference was held in New York City in June of 1895. Some of the questions set for discussion then are still interesting.

"What method shall be followed in neutralizing all media, and what standard degree of reaction shall be adopted?"

"What media shall be used for species differentiation?" (This question ie ever-present.)

"What special methods are of value in the isolation of pathogenic bacteria in water?" (Dr. Theobald Smith led this discussion.)

The meeting was a fruitful one. Active editorial work followed, and in January, 1896, a first draft of "Methods" was complete. One of the workers noted that "The report demands a very large number of necessary tests . . . Dyar recommends the use of lactose litmus gelatine and thus obtains from one medium information concerning liquefaction and acid and alkali formation, while Professor Smith's fermentation tubes provide information concerning aerobiosis, gas formation and amount of acid produced."

The report was completed in June, 1896, and was ready to submit to the A.P.H.A. It was presented at the meeting that year in Buffalo, discussed, withdrawn for further study and finally resubmitted by the chairman, W. H. Welsh, of Baltimore, for publication at the Philadelphia meeting in 1897. The report of 40 printed pages may be found in Vol. 23 of the reports and papers of the A.P.H.A. Its content was much more in line with current publications of the Society of American Bacteriologists than with "Standard Methods" in its present form. In other words, it covered the ground of basic technique rather than the special field of water examination. It is interesting to note that "Fermentation broth is

prepared in the same manner as nutrient broth except that 1 per cent of sugar is added . . ." The sugars recommended for the fermentation test are glucose, lactose and saccharose, and "These give the reaction most frequently in the order named." That casual statement in the first report was a stumbling block in reaching a judgment as to water quality for twenty years, because the growth-supporting power of the various sugars is quite different, and the sanitary significance of the result obtained is likewise different.

In 1899 a committee was appointed to extend the scope of the bacteriologists' report into a manual for use in water chemistry and biology as well. It was this committee, with George W. Fuller as chairman, that late in 1904 completed the first edition of "Standard Methods." This was a volume of 140 pages written in a chattier style than is now followed. Organized work lapsed from 1904 to 1908, when two committees were appointed to prepare a second edition. These committees worked independently—one on chemical methods, the other on bacteriological methods. The second edition appeared in 1912 and may be characterized as having contained so drastic a revision of bacteriologic methods as still to act as an inhibitor on making changes. In other words, the committee discarded the admittedly too wide group of organisms as defined by fermentation of dextrose and substituted lactose bile as the primary fermentation medium. Lactose bile not only excludes a large category of non-significant bacteria that will ferment dextrose broth but also was found in practice to exclude weak coli-aerogenes group organisms. The battle still rages as to the significance of such weak strains, but broad judgment would still indicate the preferability of using a medium that gives them a primary chance to grow, even though they may be excluded by later steps in the procedure.

Since the 1912 edition a revision organization in one form or another has been continuous. In the preparation of the third (1917) edition the bacteriological methods subcommittee had the cooperation of a committee appointed in 1915 by the Society of American Bacteriologists. The chemical methods subcommittee had the cooperation of groups from the American Chemical Society and the Association of Official Agricultural Chemists.

The 1917 text was phrased in the concise phrases now familiar to users of the text. The chattiness was entirely gone.

The most striking change was a partial return to the coli-aerogenes methods of the first edition. Between the wide group of organisms revealed by the technique of the first edition and the narrow group found by use of the second-edition method, the third took a middle ground. The general significance of these changes may be interpreted in the following terms: The first method, by the large number of positive findings that would result in finished waters, set up a very severe requirement as to degree of purification, unless it became the accepted idea that a fairly large percentage of positive findings could be tolerated in a safe water. This is not a good basis for interpretation of sanitary quality, as it will be readily granted that admissible positive findings must be limited to a small percentage of the total number of samples if the test has the proper psychological emphasis as a basis for acceptance or rejection.

The 1912 method, by the exclusiveness of its results, swung too far in the opposite direction. Since it not only exluded many non-colon organisms but also some of the colon group itself, the result was to give a higher quality rating to many waters than they actually deserved.

In 1917 the coli-aerogenes method (still standard in 1933) was adopted, which started with planting in lactose broth and was followed with the now familiar "confirmed" and "complete" tests. Upon the basis of the "complete" test of the 1917 edition has been based the main body of current interpretative opinion as to quality of finished waters. The U. S. Treasury Standard (1925) for quality of water used on interstate carriers requires its use. A mass of data now exists upon which can be based the opinion that if the "complete" test be used and, if not more than 10 per cent of the 10-ml. samples contain organisms of the coli-aerogenes group, a water may be judged safe.

A discussion that has gone on for several years revolves about the question whether or not a modification of the details of the "complete" test, involving the use of certain selective media, would not produce reliable and similar information much more promptly. Some feel that previous studies warrant such a conclusion. Others are not yet convinced. Selective media therefore appear in the seventh edition, but only for optional use on unfinished waters. It should be noted that there is a group of very experienced laboratory and public health administrators who favor the use of selective media in a way similar to that set out in the second edition of standard methods. They are quite willing to admit the exclusion of certain members of the colon group but prefer to speed up the laboratory routine rather than to broaden the test. They are willing to join in a revision of the concept of water quality, which in terms of a standard might set the permissible tolerance of colon group organisms in a safe water at 7 per cent of the 10-ml. samples instead of the present 10 per cent figure. This assumes that the net result in water quality would be an equal or slightly higher requirement than now exists. The selective action of the medium would be offset by the greater rigidity of the basis of interpretation—the protection to the water user would be equal to or greater than that effective at present, and at the same time the details of work in the waterworks laboratory would be reduced. A broad consideration of the entire problem is certainly indicated.

But there are many other things considered in the 1933 text. The section on microscopic examination of water has been completely revised under the direction of Professor Fair. The section on turbidity measurement has been rewritten by Mr. Baylis and the sections on hardness by Professor Buswell. The residual chlorine determination has been carefully restated, although it is evident that further special technique needs to be described in order that interferences due to ammonia treatment or to the presence of manganese be specifically discounted. The test for free chlorine is the first line of defence in maintaining water quality. Its limitations must be accurately described in order that the degree of its reliability be fully understood.

For the first time the text contains an appendix group of "non-standard" methods. It is well understood that a lapse of time must exist between the first announcement of a method and its full trial and general acceptance by the laboratory field. If such procedures are given no attention in the current text, many persons feel that the editorial committee is not responsive to advances in laboratory practice. But there are persons who have long held and still believe that the cover of "Standard Methods" should contain nothing concerning which any question remains. The majority of the editorial committee, however, joined in the inclusion of 23 determinations in a special section titled "Non-Standard Methods." Some of these methods will undoubtedly be included, after revision, in later texts; others will be dropped and substitute methods developed. No method was included, even in the non-standard category, that did not represent a needed determination for the laboratory worker.

During the period between the printing of the third and seventh edition of "Standard Methods," an agreement between the A.P.H.A. and the A.W.W.A. was consummated, by which joint editorial responsibility was assumed. The 1925 (sixth) edition was thus jointly sponsored. The cooperation of the American Chemical Society continues, and active interest has been taken by the Federation of Sewage Works Associations and the Great Lakes and Ohio River Board of Engineers. The continuous nature of the editorial process is now adequately recognized.

Provided that editorial activity proceeds as now outlined, it is probable that the eighth edition of "Standard Methods" will be issued in 1935 or 1936.

Notable Improvements in Groundwater Development

Hydrologic studies made by federal and state agencies in many sections allow rational design of groundwater supplies—Advances in equipment design remedy numerous former handicaps

By O. E. Meinzer
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ABOUT 6,500 public water supplies in the United States, out of a total of about 10,000, are derived from wells, according to estimates based on incomplete data recently collected by the United States Geological Survey. Most of the public water supplies are obtained from wells in virtually all parts of the United States except in New England, along the borders of the Great Lakes, and in some of the mountain and piedmont areas of the East and West.

The largest groundwater development for public supplies is on Long Island, where about 100,000,000 gal. a day are pumped for the New York City water department, and about an equal amount is pumped for other public supplies, making a development comparable in size with the major groundwater developments for irrigation. The largest city supplied entirely from wells is Houston, with 292,000 inhabitants in 1930, where about 25,000,000 gal. a day are pumped for the public supply, and about an equal amount is pumped from private wells.

Cities having between 5,000 and 25,000 population are about equally divided between groundwater and surface-water supplies; of those with more than 25,000 inhabitants, more than one-fourth obtain their public supplies from wells; and of some 8,000 cities and villages with less than 5,000 inhabitants that have public supplies about two-thirds obtain their water from wells. The 25 largest cities obtain their supplies, with minor exceptions, from surface sources; on the other hand, several millions of private water supplies, chiefly on the farms and in the smaller settlements and at industrial plants in the cities, are obtained very largely from wells of some sort. It is roughly estimated that nearly 20,000,000 people in the United States depend on public water supplies derived from wells and that 30,000,000 to 35,000,000 depend on private well supplies.

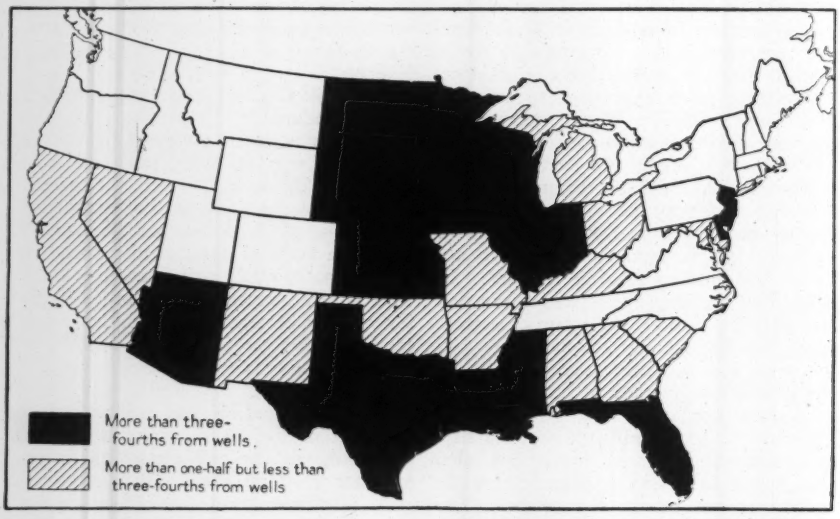
The large surface-water supplies for the great cities have been carefully planned by able hydraulic and sanitary engineers, they have been amply described in the technical journals, and they have commanded the interest of the engineering profession. The more numerous groundwater supplies have received much less attention. With the above perspective it should be obvious, however, that groundwater for both public and private supplies has an importance that can not easily be exaggerated. Moreover, it constitutes an intricate and difficult subject because of the variety of geologic formations and the complexity of geologic structure that control its occurrence, quantity and quality.

There are several reasons why, in general (but with many exceptions) surface-water supplies are best adapted for large cities and groundwater supplies are best adapted for smaller cities and villages. The great quantity of water needed by a large city can generally be obtained from one major development on a large stream or lake, or at most from a few such developments, whereas the same quantity may not be availabe from underground sources or could perhaps be developed only by sinking many widely distributed wells. The quantity needed for a smaller town, on the other hand, may be amply supplied by rock formations that underlie the locality, whereas a reliable surface supply may not be available except at a considerable distance or by the construction of a reservoir at relatively heavy cost. Moreover, within certain limits the supply can be increased as needed by sinking additional wells to the underground reservoir.

Groundwater supplies that have not been overdeveloped have, for the most part, an advantage over supplies obtained from streams with respect to permanence and reliability, due to the great storage capacity of most of the natural underground reservoirs. This advantage was rather strikingly shown in the severe drought of 1930, when relatively little difficulty was encountered with the public supplies derived from wells; and even the large city of Memphis, with a daily pumpage from public and private wells of about 40,000,000 gal., was not appreciably affected.

Groundwater is almost invariably free from dangerous bacterial pollution except in open-textured rocks, such as cavernous limestone, and in other formations near the water table in localities with surface pollution. In most cases of polluted groundwater supplies the water has been found to be pure at the source and to have been polluted after it had been pumped or by surface pollution entering the wells at the top. Moreover, groundwater has nearly uniform temperature and is relatively cool in summer; it is generally colorless and free from turbidity except that produced by the precipitation of iron oxide; and it is generally free from objectionable odor. These are great advantages to the smaller communities but are of less importance to large cities that can afford effective treatment under rigorous supervision.

In most sections of the country the groundwater has the disadvantage, for both large and small communities, of containing more dissolved mineral matter than the surface water. Because of the exacting water requirements of some industries, this may be a serious



Map showing the proportion of public water supplies derived from wells. Altogether, over 50,000,000 people in the United States depend on public and private or individual well supplies.

handicap to the use of groundwater in some of the larger cities. However, much of the groundwater is soft or only moderately hard and is otherwise of satisfactory character.

The earliest public water supplies were obtained largely from springs, wells or small streams that were not visibly much polluted or whose watersheds were protected from pollution. As it became necessary to utilize larger and more grossly polluted streams, methods of treatment were developed to make the water safe and otherwise acceptable. As effective and practicable methods of treatment became available, more of the large and rapidly growing cities turned to surface-water supplies. With the development of the simple process of sterilization by the use of chlorine, many of the smaller cities also found it advantageous to use surface water.

In the last ten or twenty years, however, notable improvements have been made along several lines in the development of groundwater supplies for public waterworks. Probably few hydraulic engineers and waterworks operators appreciate how almost revolutionery these improvements have been and how much more attractive they have made groundwater supplies for many cities.

Better methods of well construction

Great advances have been made in the methods of constructing and developing wells in formations of sand, sandstone and gravel, which constitute the principal source of groundwater in the United States. The old practice of constructing wells for public and industrial supplies consisted essentially of finishing wells, usually of small diameter, with screens having small openings that held out most of the fine-grained materials. Many of the wells thus constructed were unsatisfactory. They did not yield much water, became easily clogged and gave trouble more or less constantly. They contributed much toward making groundwater unattractive for public supplies.

Near the close of the last century and in the early years of the present century definite progress was made in the Middle and Far West in devising a technique for developing natural gravel screens and later for inserting gravel. As a result, the capacity and reliability of the wells was increased, and successful wells were finished in water-bearing materials that had previously been regarded as unproductive. A new epoch in groundwater for public supplies began when the methods for developing and gravel packing, still further improved and standardized, were introduced in all parts of the country. With the introduction of these methods came also more efficient and more durable screens and the practice of determining the size of screen openings from mechanical analyses of the water-bearing materials. A sand and gravel well of modern construction is a very different affair from an average waterworks well of two decades ago, and its capacity may be ten or twenty times as great.

Better pumping machinery

During about the same period many improvements have been made in deep-well pumps and in the engines used for pumping; and the electric motor, often direct-connected and automatically controlled, has made it practicable to operate pumps on individual wells with a minimum of attendance. The deep-well turbine centrifugal pump has been developed and brought to a high stage of reliability and efficiency. In many places suction systems drawing from a large number of wells of small capacity have been replaced by a few wells of large capacity, each equipped with a turbine pump. A notable example is the Morris station at Camden, N. J., where about 100 old-style wells with a total capacity of 18,000,000 gal. a day have been replaced by nine wells.

The turbine pump has also been adapted to serve the dual purpose of taking the water from the well and of pumping it directly into the distribution system. Thus, where the geologic conditions are favorable, it has been possible by proper distribution of the wells to maintain pressures in rapidly developing suburban areas at much less cost than if the supply were derived from a single source and it had been necessary to enlarge the service mains and operate booster stations. These improvements in the machinery and methods for pumping water from wells have reduced the cost of operating groundwater systems and have made these systems much more reliable and generally satisfactory.

Groundwater hydrology

Another influence that is tending strongly to improve the groundwater supplies and to make them more attractive for public waterworks is the effect of the systematic investigations of the groundwater conditions in all parts of the country by the United States Geological Survey and other agencies. The old idea that groundwater developments are necessarily haphazard and uncertain is being dispelled by the progress that is being made in the science of groundwater hydrology and its application to practical problems. With the improvement in methods of investigation, it is becoming increasingly feasible to determine, for practical purposes, the capacity, rate of recharge and perennial safe yield of the great underground reservoirs, to plan the groundwater developments so as to recover the maximum quantity of water without overdevelopment at any point, and to protect the underground reservoirs from needless waste and from bacterial and salt-water contamination. A notable example is the artesian basin underlying Honolulu, where the rise of the salt water and the escape of the fresh artesian water into the sea through corroded well casings caused uncertainty and anxiety in regard to the city's future water supply. Now nearly all of the defective wells have been explored with the deep-well current meter, the leaks have been located, and the defective wells have been repaired or plugged. The result has been the salvaging of about 10 m.g.d., the recovery of artesian head and the return of confidence to the people of Honolulu in the permanence of their water supply. On the basis of the quantitative studies that were made, the safe yield of the artesian basin is now known within practical limits, and systematic plans can be made for developing an additional supply from more distant sources when needed.

Groundwater investigations

About 40 years ago the United States Geological Survey began to investigate the groundwater resources of the country. Since that time its work along this line has been carried forward, often on a small scale and with inadequate funds, but nevertheless without interruption and therefore with a continuity of plan and purpose that has brought results that perhaps could not otherwise have been achieved. Much of this work has been done in cooperation with state geological surveys or other state organizations. The methods and results of the work of groundwater hydrologists in other countries have been studied and applied in this country, and in some respects we have now gone well beyond any of the other countries in the development of the basic principles of groundwater hydrology and methods of groundwater work.

The field work has been devoted chiefly to making systematic groundwater surveys of selected areas, with a view to ultimate completion of an areal groundwater survey of the entire country. This groundwater work has been built upon the vast amount of areal geologic work that has been done in this country by the U. S. Geological Survey, the state geological surveys, the geological departments of the universities and other agencies. It has resulted in the publication by the federal or state governments of several hundred reports that describe the geology and the occurrence, quantity, head and quality of the groundwater, give well records and chemical analyses of the waters from the different formations and contain maps that show the distribution and depth of the water-bearing formations and other hydrologic data. These reports furnish the base data for planning groundwater projects in the areas covered.

Quantitative studies

Early in this work the demand arose for reliable data on the quantities of

water that could be drawn perennially from certain formations in areas where large supplies were needed. In the last ten years, with increasing requirements for large water supplies and serious lowering of the groundwater levels in many places, these demands have become more numerous and persistent. Gradually there has been developed a technique for intensive quantitative work, involving both methods for determining the transmission capacities of the water-bearing formations, viewed as conduits, and methods for determining the intake and discharge of the water-bearing formations, viewed as reservoirs, and their fluctuation in storage with changes in intake or withdrawals.

Because of the great storage capacity of some of the natural underground reservoirs it may be possible for a period of years to pump quantities of water from them that are much in excess of the annual recharge. Such overdevelopment, however, must lead ultimately to depletion of the supply and excessive lowering of the water levels. In some localities it may lead to a long period of uncertainty and discouragement, with inadequate service and many ineffectual attempts to remedy a hopeless situation. If at a sufficiently early stage in the history of a water supply adequate records of water levels and pumpage are obtained and are properly interpreted, a reliable estimate of the annual recharge can be made, and orderly plans can be carried out to limit the pumpage to the safe yield, with the development of an additional supply from another source at the proper time.

Professional advice on groundwater projects

Probably the greatest weakness at present in connection with groundwater developments is the lack of an adequate body of thoroughly trained and experienced consultants to apply the available basic information effectively to the problems of the individual waterworks. Some hydraulic engineers have mastered the geologic and hydrologic principles and methods and are rendering the type of service that is needed, others could without undue effort qualify for such service, but many of them do not have the technical training for or experience in groundwater work, even though they may be very capable in other engineering work. There are also a few consulting geologists who are rendering good service in groundwater problems, but most of them have devoted themselves to oil work or other more remunerative lines of applied geology and are not sufficiently familiar with the specialized subject of groundwater hydrology. Several of the state geological surveys and other appropriate organizations have rendered valuable service in assisting the towns in regard to their groundwater problems, generally in close cooperation with the sanitary engineering divisions of the state health departments. It would appear that the state surveys have an opportunity for public service in this somewhat neglected field, especially among the smaller towns.

Better well drillers

The success of groundwater development depends in large measure on the intelligence and skill of the well drillers, whose work involves a technique distinct from that of the geologists and from that of the hydraulic and sanitary engineers. Moreover, a good share of such geologic engineering and sanitary knowledge as is applied in the development of most private water supplies and many of the smaller public supplies must be furnished by the well drillers. For many years the water-well drillers were entirely unorganized and without any trade journal, each meeting his drilling problems with such ingenuity as he possessed. The improvement already noted in the construction of large wells came chiefly through the individual enterprise of some of the foremost drillers and that of the leading firms specializing in groundwater supplies.

A significant advance in the water-well drilling industry as a whole has resulted from the organization of well drillers' associations in thirteen states, the federation of nearly all of them into an American Association of Water Well Drillers, and the publication of several trade journals, some of which reach drillers in every state. This movement originated in 1915 through the efforts of A. L. Brown, a water-well driller in Grand Forks, N.D., and is essentially an educational movement for the development of a more competent type of water-well drillers. The educational work has been conducted through cooperation by the state surveys, health departments and universities, and by the U. S. Geological Survey and Public Health Service. Much still remains to be done in providing more abundant, convenient and wholesome water supplies for the smaller communities and rural districts of our country, and the work of the well drillers must be an important factor in the accomplishment of this great task.

Chicago to Build 300-M.G.D. Pumping Plant

New Harrison St. station will replace three existing stations that have become obsolete—Pumps are to be driven by electric motors—Annual saving in operating cost to be $225,000

By Loran D. Gayton
Assistant City Engineer, Chicago, Ill.

OBSOLESCENCE of equipment, resulting in constantly increasing operating and maintenance costs, has led to the projected abandonment of three old water-pumping stations in Chicago and replacement by a single motor-driven centrifugal station. The site chosen for the new plant is on West Harrison St., in an industrial section just south of the loop area, now occupied by one of the stations to be abandoned.

At the present time the bureau of engineering of the city of Chicago operates twelve water-pumping stations. Five of these stations are triple-expansion steam-operated plants, three stations have centrifugal pumps driven by steam turbines, and four have centrifugal pumps driven by electric motors. The total installed pumping capacity of the twelve stations amounts to 1,866 million gallons daily, and of this capacity 24 per cent is in triple-expansion steam pumps, 44 per cent is in turbine-driven centrifugal pumps, and 32 per cent is in electric-motor centrifugal pumps.

Three of the electrically operated stations were originally steam plants. In one instance the pumping station is located in a residential section of the city, and there was objection to a coal-operated plant. In the second instance the cost of operating a steam plant was rather high, due to the fact that the pumping station was not located on a railroad siding. In the third case there was once a plan for the city to generate its own electricity in connection with some municipal shops, and it was thought that there would be surplus power that could be used for operating a pumping station. The surplus power failed to materialize, and the pumping station has been operated with purchased power.

The city has but one plant, the Thomas Jefferson pumping station, which was designed and built as an electrically operated station. It is located in a residential section and contains four 40-m.g.d. centrifugal pumps driven by 1,200-hp. slip-ring induction motors (2,300-volt, 3-phase, 60-cycle, 600-r.p.m.) operating against 150-ft. total head. This station was put in operation during the summer of 1928.

The New Harrison St. station is to have larger units, but in general the charcteristics of equipment are to follow those of the units in the Thomas Jefferson station.

The business section of Chicago, and what may be called the high-value area of the city, extends north and south from the mouth of the Chicago River along the shore line of Lake Michigan. The southern part of this area, extending from Madison St. south to 39th St. and extending from the lake shore as far west as Western Ave., is supplied with water by three of the oldest stations in the city, the 22d St., the Harrison St. and the 14th St. stations.

The 22d St. station was first put into operation in 1876. It was equipped with two vertical reciprocating pumping engines, with a rated capacity of 15 m.g.d. In 1884 two similar engines were added to the equipment. In 1912 two 20-m.g.d. motor-driven centrifugal pumps were installed, and in 1919 two more motor-driven centrifugal pumps were erected, replacing the old vertical reciprocating engines.

The Harrison St. station was first put into operation in 1890, with two 15-m.g.d vertical triple-expansion pumping engines. These two old pumping engines long ago became obsolete but are still in service. In 1915 a 25-m.g.d. turbine-driven centrifugal pump was added, bringing the installed pumping capacity to 55 m.g.d. Although this is a steam-operated station, it has no railroad connection for the delivery of coal, which must be hauled in by truck, thus adding to the cost of operation.

The 14th St. station was put in operation in 1892. Its original equipment consisted of three 15-m.g.d. vertical triple-expansion pumping engines. In 1889 a fourth vertical triple-expansion pumping engine was added, with a capacity of 30 m.g.d. In 1913 a 25-m.g.d. steam turbine-driven centrifugal pump was installed as reserve equipment. All of this equipment is still in service, giving an installed pumping capacity of 100 m.g.d.

Old plants costly to operate

Due to the obsolete equipment the operating costs of these three stations have been increasing year by year until now they are far out of line as compared with the more modern stations. Also the maintenance costs are rapidly becoming prohibitive. In addition to all this, operation of the Harrison St. and 14th St. stations, is made costly by the lack of railroad connection. The cost of operating and maintaining three stations of comparatively small capacity is much greater than would be the cost of one large-capacity centrally located plant.

Economy therefore dictated the erection of a new modern electrically operated pumping station to replace these three old stations, and the decision was made to utilize the grounds of the present Harrison St. station at a construction cost of $2,327,000. This new plant will be capable of pumping 300 m.g.d. against an average head of 121 ft. whereas the present three stations have a combined capacity of 274 m.g.d. against an average head of 108 ft. The annual operating cost of the new pumping station, as shown below, will be $320,000, whereas the present operating costs of the three combined old stations is more than $565,000, which means an annual saving of about $245,000.

COMPARISON OF NEW HARRISON ST. STATION WITH PRESENT 14TH ST., 22D ST. AND HARRISON ST. PUMPING STATIONS

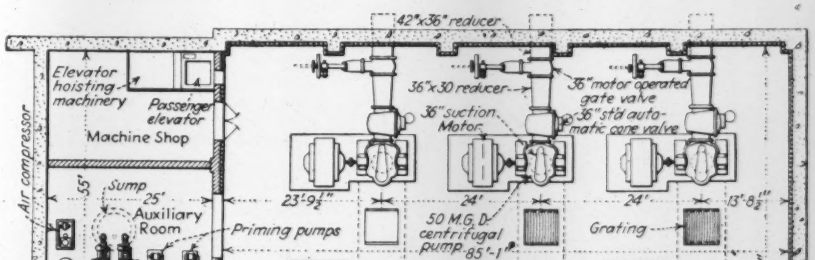
	Present (1930)	New Harrison St.
Pumpage per year, m.g.	62,362	62,362
Average head, ft.	108	121
Maximum pumpage, m.g.d.	208	225
Annual Operating Costs		
Labor	$278,290	$82,000
Coal and power	207,682	210,000
Supplies, less chlorine	13,821	2,500
Chlorine	12,516	12,516
Repairs and maintenance	50,873	12,000
Miscellaneous expense	2,610	1,000
Total	$565,792	$320,016
Annual saving		$245,776

The proposed pumping station will be 195 ft. long by 60 ft. wide. The parapet walls of the pump room will rise 42 ft. above grade, and the masonry foundations of the main part of the building will extend 34 ft. below grade. The soil at the site is a soft clay, and a supporting foundation of piles will be required. The exterior of the building will be of the best face brick with terra cotta or stone trim. The skeleton framework will be of structural-steel, and the interior of the pump pit and the main building will be faced with salt-glazed brick or terra cotta. Metal doors and window sash will be used. Complete office and toilet facilities will be provided.

Tunnels for pump suctions

Under the north end of the building a gate and screen shaft will be sunk, and a new 10-ft. tunnel will be driven from this shaft to the present water tunnel in Harrison St. Extending south from the gate shaft, two new 8-ft. tunnels will be driven, extending one on each side of the main pump room. The water will flow from the present Harrison St. tunnel through the new 10-ft. tunnel to the gate and screen shaft, where it will be chlorinated. From the screen shaft the water will flow through the 8-ft. tunnels to the suctions of the pumps. The distance between the screen shaft, where the incoming water is chlorinated, to the pumps is great enough to provide a good mixture of the chlorine solution with the raw water. The gate shaft makes it possible to isolate one-half of the entire pumping equipment at any time. Duplicate chlorination equipment of the latest design will be installed with sufficient capacity to protect the water supply of the station under peak-load conditions.

The pumping equipment will consist of six 50-m.g.d. centrifugal pumps, direct-connected to 1,500-hp., 2,300-volt, 3-phase, 60-cycle synchronous motors, operating at 514 r.p.m. The Commonwealth Edison Co. will supply 12,000-volt current, and the transformers necessary to step this current down to 2,300 volts will be provided by the same company at no cost to the city.



Equipment in the new Harrison St. station will include six 50-m.g.d. centrifugal pumps, direct-connected to 1,500-hp. synchronous motors.

In the past, principally due to starting characteristic requirements of the Commonwealth Edison Co., the city has used slip-ring induction motors for its pump drives. The new Harrison St. station is to have three supply lines direct from three Edison generating systems. This makes a cross-the-line starting possible and gives the city the choice of squirrel-cage or synchronous motors. The lower price and higher efficiency to be obtained with synchronous motors of these sizes and speeds determined the choice of type. The Edison rate structure gives no inducement for improved power factor beyond requiring a minimum of 85 per cent. The three direct services from the Edison

generating stations are brought into the station and connected without circuit breakers to three 5,000-kva. 3-phase transformers, which step down the voltage from 12,000 to 2,300. The metal-clad switch gear on the 2,300-volt circuits will be arranged normally to carry two motors on each transformer with provision by bus ties to carry in an emergency all six pumps on one bank of transformers.

Each pump will be provided with a suction-gate valve, and the discharge from each pump will be provided with a check valve and a gate valve. The discharge system from the station will make it possible to send the whole or any part of the pumpage in any one of four directions, thus giving a flexible control of the entire station output. The electrical-control equipment, cranes and other miscellaneous accessories will be of the highest type of design and construction.

Under normal operating conditions this station will supply water to an area of 13 square miles, but due to the flexibility of the discharge system, if it should become necessary in case of a major fire in the high-value area of the city, this station could throw a tremendous volume of water into that section.

In essence, this proposed centrally located pumping station will supply a long-felt want by giving an important part of Chicago added service and fire protection, and at the same time the project will show a great saving in cost of operation.

The plans for the new Harrison St. pumping station are nearing completion, but no actual construction has as yet been started. Before beginning construction of the new plant it will be necessary to shut down the present Harrison St. station and to remove all the existing buildings and equipment from the site. Proposals have been received for dismantling the present structures and for the purchase of the pumps, motors and venturi meters, but as yet no contracts have been awarded. At present the indications are that the work of removing the present structure and the construction of the new station will be started some time during the present summer.

Equipment Progress Aids Pumping and Distribution

Pumps, pipes, valves and services have shared in the general advance toward efficiency, durability and lowered operating costs

By Theodore A. Leisen
General Manager, Metropolitan Utilities District, Omaha, Neb.

A CENTURY OF PROGRESS has developed changes and improvements in the various details of water supply that are in keeping with progress along other lines of industry. Some of these developments are noted in this article, with particular reference to the latter half of the century, a period representing the active life of a few men who still are devoting their energies to public water-supply problems. Some of the advances, improvements and changes in pumping equipment, in distribution systems, and services which have taken place over the last generation are given, without any attempt to adhere to strict chronology of the developments.

Pumping machinery

In reciprocating types the evolution from the Cornish pumps to the modern vertical triple-expansion crank-and-flywheel pumping engine exhibits one of the most outstanding improvements in mechanical equipment. The Cornish type of pump, at best an apology for good mechanical principles when applied to water-supply service, consisted of a single-acting steam cylinder which, operating by means of a walking beam, raised a counterweight, and this in its descent by gravity actuated the pump plunger.

The Cornish pump, originally designed for mining use, met with some favor about the middle of the last century for municipal waterworks, among the best examples being the two units installed at Louisville, Ky., in 1860. These two pumps, having a combined capacity of 12 m.g.d., continued almost uninterruptedly to furnish the water for Louisville's requirements for more than 30 years and were utilized for nearly twenty years longer for a part of the supply.

The transition period of more than a quarter of a century, representing development from the Cornish to the vertical triple-expansion pumping engine, was productive of a number of designs in both low-duty and high-duty pumps, and many arguments resulted as to the relative merits of the low- and high-duty types. Gradually the high-duty units gained in general favor, and all manufacturers strove toward greater efficiency at moderate cost. This competition brought out certain standard types that could be produced at a lower cost than special designs and in consequence narrowed the field to a comparatively few manufacturers.

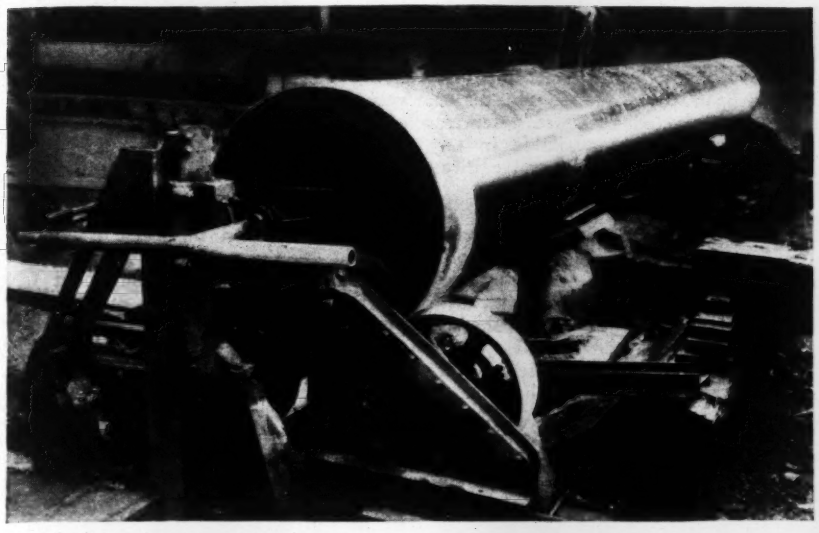
A few of the designs were freakish or eccentric in nature, but even these aided in the steady improvement and were factors in the final adoption of the basic principles embodied in the best standardized designs. Efforts to eliminate the crank and fly-wheel resulted in direct-acting pumping engines with balancing or compensating devices. Many of these still are in operation.

Among the pumping engines of larger capacities and special designs the Leavitt compounds stood out pre-eminently for high efficiency and reliability, but their initial cost was high and, possibly for this reason, only limited numbers were ever built.

Increasing efficiencies

Efficiencies, as represented by the duty attained, have increased steadily from around 40,000,000 to about 200,000,000 ft.-lb. per 1,000 lb. of dry steam. Most of this increased efficiency is due to improvement in design, which cut down clearances and made available all the benefits of steam expansion, but part can be attributed to the higher boiler pressures and superheated steam now in general use.

Eight motor-driven centrifugal pumps supply water to Oak Park, Ill., operating either as boosters for the Chicago supply or take their supply from a 5-m.g. reservoir filled at night from the Chicago mains.



Straight-end welded steel pipes, with lengths joined by welding or by bolted-sleeve couplings, are used for the new supply main built by the Panther Valley Water Co., in Pennsylvania. This view shows the equipment used for centrifugal application of bituminous lining

Despite the efficiency and reliability of that highest make of reciprocating pumping engine, the vertical triple-expansion crank-and-fly-wheel type, it is safe to predict that few will be built in the future, because the fixed charges on the initial cost of the pumping engine and building necessary to house an engine of its dimensions are so far in excess of analogous charges for a centrifugal pump installation of equal capacity as to more than offset the economic advantage due to greater operating efficiency.

Rapid and radical strides have been made in both the design and application of centrifugal pumps for public water-supply service through improvement in design and application of the multi-stage principle. Because of the facility for operating this class of pump either with a steam turbine and reduction gears or by direct connection to an electric motor, and due to the small space required to house it and its low initial cost, it is rapidly superseding the reciprocating pumping engine.

Practically all of the development of the centrifugal pump has occurred within the present generation. Originally designed and accepted as a medium for use in pumping water against low heads, and with poor economic efficiency, it has been improved to the point where it competes successfully with every other class of pumping equipment, against any head required and for any capacity up to the limits of ordinary demands.

A recent installation of a single-stage 35 m.g.d. centrifugal pump to operate against a pressure of 115 lb., or 265-ft. head, indicates what has been accomplished with but one impeller. With the multi-stage type there is practically no limit to the head for which they can be designed. Relative to capacities pumps having a daily capacity of 50 m.g.d. against heads of 200 ft. are not unusual.

The invention of the steam turbine was a potent factor in permitting the development of the centrifugal pump to its present stage of efficiency, and the electric motor further aided to broaden the field for its use. While there exist some centrifugal pumps operated by reciprocating engines, it is obvious that either the steam turbine or the electric motor affords the ideal motive power for this class of pump.

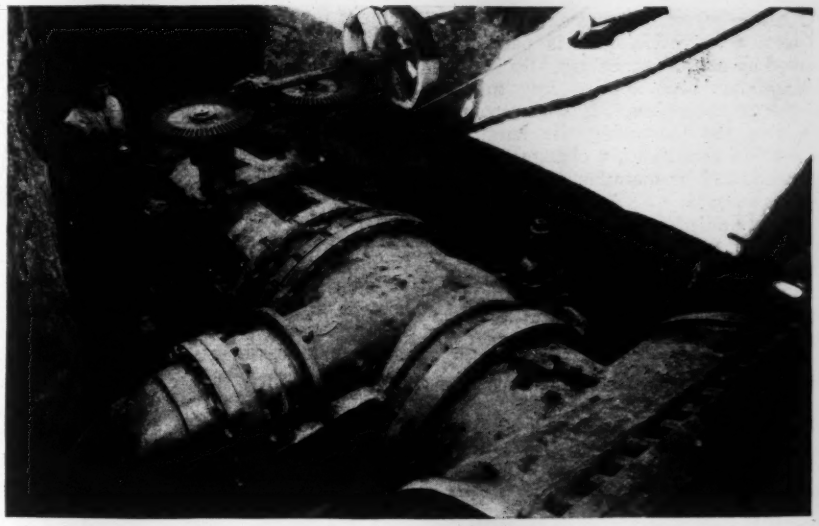
While the reciprocating pump is not obsolete, the centrifugal pump looms up on the horizon of the future as its inevitable successor for general waterworks service.

Distribution

Water under pressure requires some form of closed conduit for its distribution system, and from the incipient stages of waterworks development in this country only three classes of material have been used for such conduits: wood, concrete and iron. Or, if it is desired to differentiate between iron and steel, the latter may be mentioned as a fourth class. The term "distribution system" as used here does not include the service pipe supplying individual consumers.

No authentic data are at hand to determine what classes of mains were first used in this country for distributing water supplies, but it is known that some cities used pump logs for the purpose, and these represent the first use of wood pipe in distribution systems. However, while this may have some historical value, these bored logs were used to a very limited extent and probably did not antedate the use of cast-iron pipe.

For many years cast iron was the only material used for water pipe, and few innovations were made and little progress was shown in the methods employed in casting pipe until quite recently. Originally all pipe was made in short lengths and cast in a horizontal position. There was a tendency for the molten iron to force the core up from its central position, leaving the upper wall of the pipe thinner than the lower wall, and as a natural consequence breaks would occur on the thin side when subjected to pressures that a pipe of uniform thickness would have withstood.



Making a 36-in. connection to a 48-in. main under pressure by use of a large power-driven tapping machine.

The first step in advance was the change to casting in vertical molds, allowing the lengthening of the pipe to standard 12-ft. lengths and insuring greater uniformity in thickness. Parenthetically, it may be noted that certain manufacturers still continue to cast in a horizontal position, claiming the ability,

by proper device, to maintain the position of the core, and claiming also, by this method, more uniform character of iron throughout the full length of the pipe.

Bell-and-spigot pipe has been the standard form, with few essential changes, for all sand-cast pipe designed for the use of lead-caulked joints. Until quite recently all pipe was fabricated in 12-ft. lengths, 3 to 48 in. in internal diameter and to somewhat larger diameter on demand. It is furnished in several different wall thicknesses to conform to required pressures. A large majority of all the pipe in use by waterworks throughout the country is of the character described.

The first striking innovation in the manufacture of cast-iron pipe was the Delavaud method of centrifugal casting in a revolving iron mold, resulting in smoother surface, more uniform thickness and higher tensile strength, but producing a chilled surface or case-hardening effect that increases its brittleness, a condition that is partly removed by careful annealing. So far this method has been applied only to pipe of the smaller sizes. It was responsible also for increasing the length of pipe to 16 and 18 ft., a change that has been adopted by manufacturers of other classes of pipe.

Closely allied to the above is the sand-spun pipe, where the mold is lined with sand to eliminate the case-hardening, and which, the manufacturers claim, reduces the brittleness. Because of a lower cost at the foundry and reduced freight rate on account of lighter weights, both the Delavaud and sand-spun pipe are being extensively used in places where heretofore sand-cast pipe held full sway.

Wood-stave pipe, developed originally in sections where timber was plentiful and cast iron scarce and expensive, has had its advocates and has been used extensively in the West, particularly for main supply lines. It came into general use at some of the army cantonments for the complete distribution system.

In the larger sizes, from 30 in. and upward in diameter, pipe fabricated from steel plate has become a competitor with cast-iron pipe, based on the difference in delivered cost. The earlier examples of steel pipe used for water supply were composed of sheets riveted both longitudinally and circumferentially, and some disappointment occurred on account of the excessive frictional losses caused by the numerous riveted seams, resulting in a material difference between its actual carrying capacity and that calculated by accepted hydraulic formula.

The first departure from the all-riveted steel pipe was the lock-bar type made in 30-ft. lengths, with no longitudinally riveted joints and but one circumferential joint every 30 ft. Several miles of this pipe, 43 and 48 in. in diameter, were laid in this country in 1905, and since then numerous other lines have been laid.

More recently welded-steel pipe has been utilized for large supply mains, with joints riveted at 30 ft. intervals. Welded-steel pipe is available in any thickness of plate and any required diameter.

Concrete conduits of various sizes have been used extensively for gravity supplies, and reinforced-concrete pipe now is being supplied to resist any pressure that the ordinary water system would demand. It is furnished in short lengths, and the special type of joint is claimed to be absolutely watertight. Report on a 60-in. line laid a few years ago confirms this claim.

For the small distributing mains laid through city streets, cast-iron pipe in some form, either sand-cast or the later types—Delavaud and sand-spun—may be considered still the most reliable and safest to use and most convenient for tapping.

Valves

Gate valves have not undergone any radical changes for many years, although minor improvements have been in evidence and increased tensile strength of the bronze stems has been an important factor. The early types of side-action rack-and-pinion valve still exist in some systems but are rapidly becoming extinct. Valves with solid wedge-shaped disks are adhered to by certain cities, but the double-disk parallel-seat gate valve has become the general standard.

Check valves have shown improvements in design, the original flap valve having been superseded by the balanced swing check. More recently the needle valve and the cone-plug check valve operated by hydraulic control are coming into more general use.

An improvement of merit is the tapping sleeve and valve, which permits the tapping of a main and insertion of the gate valve on the branch without shutting off the pressure. Another important advance is the equipment for inserting a valve in the main under pressure without interfering with its normal flow.

Services

For service connections from the mains to the premises of consumers, lead pipe superseded wrought-iron or steel pipe for small sizes, up to 1 in. or 1½ in., and its use has become practically universal.

About twelve years ago copper pipe became available for this purpose and can be furnished up to 2 in. in diameter. Both lead and copper pipe are in general use at the present time for service connections.

The first method of tapping a main for the service connection consisted of drilling a hole in the main and driving a tapered plug with a plug cock attached into the hole, friction alone being relied upon to hold the plug in place. The present type of corporation cock, together with the devices for inserting under pressure, although not new, represents the latest development along this line.

Letters to the Editor

Divergent Views on Valuation

Sir—The controversy over the question of valuation of public-service properties has continued for more than 50 years. The owners of public utilities are divided into two groups: one contends that original cost, or prudent investment, is the rate base, whereas the other group argues that cost of reproduction is the rate base. Your editorial entitled "Turning the Tables," on p. 658 of the issue of Dec. 1, 1932, calls attention to this controversy and contains the statement:

> When times were good and prices were on the uptrend, public utilities sought to have their properties valued for rate-making purposes on the basis of the cost of reproducing the property at current prices of material and labor.

Human nature does not change. Public-service companies naturally desire to protect their properties by claiming that present value is the rate base. The question is how to determine present value.

I call attention to the letter dated July 7, 1932, of C. E. Grunsky, past president, American Society of Civil Engineers, on p. 586 of *Civil Engineering* for September, 1932. Mr. Grunsky takes the position that:

> The natural rate-base is of course the legitimately invested capital, corrected for the relative purchasing power of the dollar, and without diminution by accrued depreciation. This is of course not the only rate base that can be used, although it is by far the most convenient.

I also quote from an article entitled "Some Recent Problems in Public Utility Valuation and Regulations," by Shirley D. Southworth, printed in the *American Economic Review* for December, 1922, p. 611:

> The size of the value measuring stick has changed, and the public utilities should not be expected to stand aside and say that a fifty-cent dollar is the same thing as a hundred-cent dol-

lar. The amount of the investment should be expressed in terms of the present dollar. The only feasible method of doing this would be to take some official index number of wholesale prices such as that of the Bureau of Labor Statistics as an indicator of the value of money. When this showed that the value of money had gone up or down, the figure representing the investment would be made to fluctuate by a like percentage.

The United States Supreme Court, in the case of United Railways & Electric Co. of Baltimore, decided Jan. 6, 1930, stated that:

> It is the settled rule of this court that the rate base is present value, and it would be wholly illegal to adopt a different rule for depreciation.

The United States Supreme Court also stated in the case of the Indianapolis Water Co.:

> And, as indicated by the report of the commission, it is true that, if the tendency or trend of prices is not definitely upward or downward and it does not appear probable that there will be a substantial change of prices, then the present value of lands plus the present cost of constructing the plant, less depreciation, if any, is a fair measure of the value of the physical elements of the property.

The Supreme Court has recently clarified the valuation question. On May 8, 1933, it decided the case of Los Angeles Gas and Electric Corp. vs. Railroad Commission of the State of California. The valuation of the property was the main question at issue. Mr. Chief Justice Hughes delivered the opinion of the court. Among other things, the court stated:

> This court has repeatedly held that the basis of calculation is the fair value of the property, * * * at the time it is being used for the public. In determining that basis, the criteria at hand for ascertaining market value, or what is called exchange value, are not commonly available. The property is not ordinarily the subject of barter and sale and, when rates themselves are in dispute, earnings produced by rates do not afford a standard for decision. The value of the property, or rate base, must be determined under these inescapable limitations. And mindful of its distinctive function in the enforcement of constitutional rights, the court has refused to be bound by any artificial rules or formula which changed conditions might upset. We have said that the judicial ascertainment of value for the purpose of deciding whether rates are confiscatory is not a matter of formulas, but there must be a reasonable judgment having its basis in a proper consideration of all relevant facts.
>
> The actual cost of the property—the investment the owners have made—is a relevant fact. But while cost must be considered, the court has held that it is not an exclusive or final test. The public have not underwritten the investment. The property, on any admissible standard of present value, may be worth more or less than it actually cost. The time and circumstances of the outlay, and the effect of altered conditions demand consideration. . . .
>
> But no one would question that the reasonable cost of an efficient public-utility system is good evidence of its value at the time of construction. We have said that such actual cost will continue fairly well to measure the amount to be attributed to the physical elements of the property so long as there is no change in the level of applicable prices. . . .
>
> This court has further declared that, in order to determine present value, the cost of reproducing the property is a relevant fact which should have appropriate consideration. . . . But again, the court has not decided that the cost of reproduction furnishes an exclusive test. . . . The weight to be given to actual cost, to historical cost and to cost of reproduction new is to be determined in the light of the facts of the particular case. . . .
>
> The determination of present value is not an end in itself. Its purpose is to afford ground for prediction as to the future. It is to make possible an intelligent forecast of probable future values in order that the validity of rates for the future may be determined.

The decision in the Los Angeles case is a notable one. The court reaffirmed its former decision that the present value is to be determined and "refused to be bound by any artificial rules or formula which changed conditions might upset."

Washington, D. C.,
May 20, 1933.

EDWIN F. WENDT,
Consulting Engineer.

Brick in the New York Code

Sir—The comparison of the present and proposed building codes of New York, which appeared in your issues of April 20 and 27, is extremely interesting. I believe, however, that some of the differences exhibited, especially in the masonry section, will be more clearly understood if an explanation is offered.

The numbers of A.S.T.M. standards mentioned in the proposed code were correct when it was drafted, but since that time certain numbers have been changed, as for example C62-28 T to C62-30, which simply means that a tentative standard has been accepted. This does not imply any change in the requirements of the specification.

Under the heading "Brick" in Mr. Miller's article, it certainly was not intended to preclude the use of higher quality brick than the B grade; in fact reference to working stresses will show that provision was made for the use of a higher strength product. Both sand-lime and concrete-brick standards are covered by paragraph 1.15, which states ". . . Similar structural units made of other substances, such as lime and sand, cement and suitable aggregates or fire clay which meet the strength requirements of 7.1.1.2.1 (Brick) or 7.4.2.5 (Requirements for Other Structural Units) shall be considered as brick within the meaning of this code." The principle that materials permitted to be used for the same purpose should meet the same quality standards would seem to be entirely sound.

Mr. Miller assumes, under the heading "Mortar," that only portland cement is admissible, but reference to paragraph 7.1.1.9 (Other Mortars) will show that any mortar may be used provided it meets standards set up in that section.

The question of masonry-wall thickness has been argued at some length. Without questioning Mr. Miller's figures it is possible to assume heights of both building and stories that will show considerable savings over the present code requirements. It seems to be a case where the differences in masonry quantities between the two codes is not subject to a hard and fast rule but varies according to story heights and total height of a particular building. In many, if not most, typical buildings a saving will result from the adoption of the proposed code.

The criticism has been made that brick working stresses are too high. First of all, it should be realized that, according to U. S. Bureau of Standards tests, the average compressive strength of brick used in New York is about 4,500 lb. per sq.in. The same authority, in an investigation of masonry-wall strength lasting some two years, gives the average solid wall strength of brick of somewhat lower grade as 1,510 lb. per sq.in., so that the stress of 325 lb. in cement mortar, permitted by the proposed code, is well within the factor of safety of 4 used in connection with other masonry. Further, the Department of Commerce code committee, of which Mr. Miller is a member, recommends stresses of either 175 or 250 for 4,500-lb. brick, depending upon whether the brick strength is slightly under or over the 4,500-lb. figure. If we average these stresses (212 lb.), and then add the statement from the Department of Commerce code that where good workmanship is the rule and allowances are made for concentrated loads, lateral forces, etc. (a requirement of the proposed code), the recommended stresses may be increased by 50 per cent, the total stress permitted by the Department of Commerce code becomes 318 lb., which is practically the same as the 325 lb. permitted by the proposed code.

It should, I think, be realized that the committee preparing the New York proposed code submitted the draft to a very large number of architects, engineers, contractors, etc., as well as to the various city building departments, all of whose suggestions and criticisms were carefully considered and in many cases adopted. One might almost be justified in saying that the provisions of the proposed code are no longer the work of the committee, but rather the consensus of opinion of the building interests of Greater New York.

R. S. TILDEN,
New York & New Jersey Common Brick Assoc.
New York, N. Y.
May 11, 1933.

Engineering News-Record

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Looking Ahead

LIKE most other human concerns, the service of water supply has passed through one of the hardest years in its modern history. It now looks ahead to a time of new and vigorous activity. In preparation for this new growth the occasion of the leading gathering of water technicians inspires a brief look at the course of progress of the art, as a guide to the road of further advance. The meeting fitly is timed in conjunction with the celebration of a century of progress. Water-supply development proceeded far in that century, and indeed its rate of advance was accelerated in each new decade, as is fairly reflected in the remarkable evolution of the Chicago water-supply system and its problems. A group of articles in this issue gives a broad perspective of this advance, in order to point out the present trends of progress and aid the engineer to forecast the future more truly. Examining the subject as a whole, he will find that the water art gives faithful expression to the steady increase in standards that marks all of modern technical life, and that his own future work in advancing the art will have much to do with raising human existence to a higher plane.

Steady Progress

INTENSE activity has been displayed by Congress in dealing with the public-works bill, and the result indicates steady progress toward passage of the bill, substantially in the form first proposed. Changes in both the industry control and the public-works sections have been proposed, but they are minor in effect and appear likely to yield before final passage, when Congress finds that they do not strengthen the bill. Thus, restriction of highway expenditures to federal-aid roads (as provided by a Senate amendment) is unnecessary for protection of the national treasury and is bound to have a harmful effect in reducing the volume and speed with which employment can be built up. Again, the insertion of specific allotments to forest and park roads serves no useful purpose and does not promote rapid relief of unemployment. Such changes, it may be hoped, will be eliminated before the final passage. In the meantime state and city officials are displaying great activity in developing local programs, and public-works construction is sure to start quickly as soon as the bill passes.

No Charity Measure

ONE ELEMENT of the Recovery Act needs constant iteration. The Administration does not look upon the act as a charity measure or as a means of providing jobs upon which the unemployed can be put to work regardless of their fitness. It looks upon the act as a means for reviving *all* industry, thus putting men back to work in their *normal occupations*, be they sign painters or haberdashers. Especially the state and city officials who will be charged with the detailed planning of work should keep this fact in mind. The handwork doctrine that gained such wide support during the past two years must be definitely abandoned. Specifications, subject only to the 30-hour week required by the act, must call for the work to be done by normal methods, with all the tools and equipment that efficient construction implies. For, unless much of the money that will be provided under the act is put into circulation in as many channels as possible in the shortest possible time the act will fall short of its aim of stimulating *all* industry. Its effect must be made to reach out to the producers of materials and equipment through expeditious handling of the work by experienced contractors.

Organizing for Results

IN ORGANIZING to take over the responsibility of industrial self-control under the first title of the recovery bill, industry associations are finding that they have real problems to meet. Their past activities are casual and unimportant compared with the new regulatory functions. Casual attitude or method will not suffice in dealing with the complex problems of employment extension and stabilization, prevention of reckless competition, elimination of unsound practices and regulation of production that the act envisages. Past conditions favored extensive differentiation of industry groups, as small groups were easiest to operate and maintain, but for the new purpose the very opposite is essential. The government's supervision of industry groups cannot deal with a vast number of small organizations often differing but little in production and market conditions. Intimations to this effect have already come from Washington, and they give new force to what we said during the last fortnight in favor of maximum concentration of the many separate unit organizations of the construction industry. The effectiveness with which the machinery, materials and construction interests are brought together in large comprehensive groups will have much to do with determining how quickly construction is restored to sound condition.

Taxes on Materials

CONTRACTORS in states where retail sales taxes have been imposed will find it valuable to study the application of those taxes to the purchase and use of materials for construction operations. A summary of how the New York tax applies to contract work in that state was given in our news page last week. The rulings of the tax department will be seen to be logical and, as a conscientious effort is being made to minimize the nuisance features of the tax, the department is entitled to full and willing cooperation of contractors. So far as the general lump-sum or cost-plus contract is concerned, the tax is collected on the sale of materials to the contractor; in special contracts, where there is a resale of material to the owner by the contractor, or under conditions where the contractor applies part of the material purchased to a lump-sum contract and sells the remainder, special provision is made for the collection of the tax. It should be noted that under the New York law the tax applies only to sale to the consumer; sales taxes of broader application by their terms may affect construction work more extensively.

PROGRESS IN WATER-SUPPLY PRACTICE

THE WORD PROGRESS is in the air as the waterworks engineers of the country gather for their annual meeting at Chicago. Not only is there on display in that city today a huge exhibit that gives visible expression to the forward strides made in applied science during the past century, but the waterworks men themselves will spend a profitable week gathering from their fellows the latest information on recent advances in the art and science of supplying water to communities.

Although our material fortunes have been at a low ebb for the past few years, advance in the practical application of scientific achievements has not been halted. Progress in science and engineering has an amazing vitality; economic dislocations affect it but little. This is as true of water-supply engineering as it is of any other field of service. Waterworks practice is far different today from what it was but a few years ago. Pumping and distribution equipment give much better economy, purification methods are almost universally employed, disagreeable tastes and odors in purified water can be largely avoided, treatment preliminary to filtration is given great attention. Further, increasing refinement in consumer service standards is giving rise to correspondingly increased refinements in water quality.

IT IS particularly fitting at this time that we should examine the present status of waterworks practice. Without question the operation of the Recovery Act now pending in Congress will bring about a great revival in the construction of water-supply facilities, allowing a multitude of communities to provide themselves with some of the improvements and extensions that they have been forced to defer during the past few years. Needless to say, if the new construction is to be economical and properly effective it must embody the latest that is available in waterworks knowledge. It is with this thought in mind that we have prepared the present issue of *Engineering News-Record*, devoted to the progress made within the past few years.

In keeping with the spirit of the Chicago meeting of the American Waterworks Association, the present issue is introduced by a historical account of Chicago's water system. The great strides that this city has made in supplying its growing population with ever-mounting quantities of water are particularly valuable in retrospect, as they have run parallel with the advances made in the country as a whole. But this historical account, as well as the following review of the present advanced state of general purification practice, merely emphasizes the steps that still must be taken to bring Chicago's supply up to the standard of quality demanded today.

Filtration is the next step to be taken to serve properly the water needs of Chicago's population. The need for the step is acknowledged; plans are ready, and only finance is the obstacle. When the pending public-works program gets under way there is no more proper object for its attention than this city's filtration needs. The metering of Chicago's supply, of course, still remains as a prerequisite for filtration, if filtration costs are to be within reason. A proper program of purification-plant construction must include this measure.

The advance in water-supply practice in recent years has been most rapid and extensive in the field of water purification. More thorough conditioning of the water prior to filtration has been brought about by increased knowledge of coagulation phenomena, better mixing basins and improved mechanical equipment for flocculation and sludge removal. The result has been increased economy and improved filter performance. Filters themselves have changed little in fundamental design, but improvement of their operation has been made possible by better knowledge of filtration principles. Not so long ago, sterilization practice frequently occasioned highly disagreeable tastes and odors in the purified water; but today the taste-and-odor problem may be considered largely solved, by virtue of the application of chloramines and activated carbon.

ALTHOUGH softening has not by any means come into universal use, softening methods have shared generously in the general purification advance, largely through recarbonation; removal of hardness-forming compounds can now be carried to much greater lengths than formerly without danger of forming deposits in the distribution system. All these improvements in purification practice increase the number of tools available to the waterworks engineer to provide his community with an adequate supply of safe, attractive water.

But progress in water-supply practice has not been confined to the field of purification. Perhaps the most striking change that has taken place in the past generation has been the almost complete supplanting of the imposing direct-acting pump by the smaller, less costly, more flexible centrifugal pump. In this particular case the change has been made despite the higher operating efficiencies of the reciprocating unit; the tiny centrifugal pump allows such a low first cost that savings in capital charges more than make up for losses in efficiency. No longer does the visitor to the pumping station stand gazing in admiration at a laboring puffing giant that forces the water through the mains to his home; a whirring little demon has taken its place. The change has been sad for romance but good for economy.

Pipe-line materials, too, have benefited. Cast-iron pipe, long a standard material for water systems, shares in the advance by making use of new methods of manufacture, yielding stronger pipe at less cost. The advance in welding practice has contributed greatly to the usefulness and economy of steel pipe. Lining materials, too, have been improved and increased in number to lengthen further the useful life of the pipe line.

ASSOCIATIONS of technical men, like the American Water Works Association, have played a large part in the progress that has been made. Their part is well illustrated by the production of such standard reference works as "Manual of Water Works Practice" and "Standard Methods of Examination of Water and Sewage." It is in the meetings of these associations that the most recent progress made is reported upon and discussed. Continued support of such cooperative efforts is essential if the present rate of progress is to be maintained. And further progress is the indispensable necessity, if the art is to be continued to meet man's growing requirements. Of this fact we have proof in the events of the century of progress now closing.

NEWS OF THE WEEK

Contract Let for Large Bridge Over Hudson River at Catskill

The bid of the Frederick Snare Corp., New York, of $2,165,601 for the proposed Rip Van Winkle Bridge over the Hudson River was the lowest of twelve received by the New York State Bridge Authority when the bids were opened by the Superintendent of Public Works on June 1. On June 5 the contract was let to the Frederick Snare Corp.

The second low bid was submitted by the Walsh Construction Co., Davenport, Iowa, $2,192,140. Other bids were submitted by the Raymond Concrete Pile Co.; Rodgers & Hagerty, Inc.; P. T. Cox Construction Co.; George A. Fuller Co.; J. F. Coogan Co.; Rosoff Subway Construction Co.; I. M. Ludington & Son, Rochester; Delbalos Construction Corp.; Booth & Flinn, Pittsburgh; and the Arundel Corp., Baltimore.

The engineer's estimate of the cost of the work was $2,671,215.

Construction of the bridge is being financed by the Reconstruction Finance Corp.

Mississippi Cuts Through Bend in Advance of Planned Opening

A celebration in connection with the making of the last cut in the channel across Giles Bend in the Mississippi River, two miles above Natchez, Miss., scheduled for June 10 by the U. S. army engineers in charge of the work, was eliminated on May 25 when the river took the completion of the channel in its own hands and cut through the last remaining section of the narrow neck of land.

Since March 20 dredges and dragline excavators have been cutting a new channel 10,000 ft. long, 200 ft wide and 40 ft. deep across Giles Bend to save the 20 miles of distance required to pass around the bend.

The cut across Giles Bend is being made by the army engineers as the result of tests carried on in the hydraulic laboratory at Vicksburg which showed that such river bends could be eliminated without resulting in serious damage. For many years past the natural bends have been preserved for fear that the change in river slope caused by cutting off a bend would result in dangerous erosion further down the river.

Power Line Contract Approved Boulder Dam to Los Angeles

The Supreme Court of California has upheld the validity of a contract between the water and power department of the city of Los Angeles and the Reconstruction Finance Corporation whereby the corporation agreed to loan $22,800,000 to the city for the construction of a high-tension transmission line between that city and the power plant at Boulder Dam.

Public Construction Under Recovery Act Advanced by States

IN ANTICIPATION of the early passage of the industrial recovery bill with its provision of $3,300,000,000 for public works, many states and cities have begun definite plans for work to be financed under the provision of the public-works section of the proposed act. Under that section, except for the outright grant to the states for highway construction, grants up to 30 per cent of the cost of labor and material are to be made to states, cities and counties and the remaining 70 per cent may be borrowed from the federal government.

New York State work

The New York State public works commission has prepared for immediate presentation to the administrator of the recovery act a program calling for expenditure of $350,000,000, including $98,000,000 for self-liquidating projects, $25,000,000 for housing, $25,000,000 for federal-aid highway projects, $50,000,000 for railroad grade crossing separation, $15,600,000 for hospitals and public institutions, $15,000,000 for county projects, $3,000,000 for town and special district projects, $3,000,000 for village projects, $150,000,000 for city projects.

Large items included under the self-liquidating projects, projects that have been presented to the Reconstruction Finance Corporation but have not yet been acted upon, are $38,000,000 to build one tube of the projected 38th St. tunnel under the Hudson River at New York; $14,000,000 for the Pelham-Port Chester Parkway; $3,250,000 for construction in the Saratoga Springs reservation; $40,000,000 for the Triborough Bridge at New York; $900,000 for a planetarium at the Museum of Natural History, and $2,000,000 for development of the State Fair grounds.

New Jersey projects

Late in May Governor Moore of New Jersey appointed a committee to assemble information on projects suitable to be financed under the recovery act. Projects put forward for early consideration by that committee include $19,000,000 of grade crossing work which is ready to be put under contract, $8,000,000 for the South Jersey Port Commission, $40,000,000 for the North Jersey District Water Supply Commission, also construction of the high-speed line over the Philadelphia-Camden Bridge.

Ohio projects

The Ohio work project development committee estimates that it can put forward $120,000,000 worth of work at an early date.

In Cleveland, a local committee appointed by the mayor, is planning to expedite the financing of the city's proposed $700,000 garbage disposal plant, $2,000,000 for street extension work, an additional amount of $3,000,000 for sewage disposal, and $3,250,000 for river straightening and lake front improvement. The committee also is considering an application for $3,600,000 for a housing project.

Missouri work

Expenditure of $51,500,000 for public and private construction in Missouri has been recommended to the state committee appointed by the Governor by the Construction Council of Missouri. This includes $5,000,000 for public buildings, $9,000,000 for bridges, $10,000,000 for highways, $8,000,000 for commercial and industrial buildings, $5,000,000 for utilities and related facilities. In St. Louis one of the first projects that is expected to get under way is the federal post office for which the government has already purchased a site.

Work in other states

The Louisiana committee for trade recovery has prepared a detailed list of over 2,000 projects totalling $160,000,000 that may be financed and built under the recovery act.

In Indiana state officials estimate that $75,000,000 can be spent profitably on public improvement work. The highway department is preparing plans to let $2,500,000 of new work as soon as money is available.

Cities Plan for Power Supply from Muscle Shoals Plant

The city commission of Florence, Ala., has called for a special election on June 30 to consider a $300,000 bond issue for the construction of an electric distribution system, also to authorize the city commission to enter into an agreement with the Tennessee Valley Authority for the purchase of power from the plant at Muscle Shoals under the provisions of the federal act creating that body.

A similar proposition was put to the voters of Sheffield, Ala., recently and the town of Tuscumbia is considering like action.

The city of Memphis has appointed a special board to look into the possibility of purchasing power from Muscle Shoals and constructing a transmission line to the city.

Kentucky Buys Bridge Bonds

Bridge bonds totalling over $44,000 at the present market value, $2,800 under the par value, were purchased by the Kentucky Highway Commission on May 23. This action was taken under a policy recently adopted of using the surplus funds from tolls collected on its toll bridges for the purchase of bridge bonds when such bonds are being marketed well below the par value.

Newark Seeks R.F.C. Loan To Complete Subway Project

The city of Newark, N. J., has applied to the Reconstruction Finance Corporation for a loan of $3,500,000 for the completion of the rapid transit subway line in the bed of the old Morris Canal. Of this amount $2,500,000 would be for new work and $1,000,000 to reimburse the city for money already spent.

Since the application was made, the city has been advised by the directors of the R.F.C. that it can only consider an application for a loan to cover new construction.

President Completes the Board to Direct Tennessee Valley Work

J. H. A. Morgan, president of the University of Tennessee, Knoxville, Tenn., and David E. Lilienthal, member of the Wisconsin Public Service Commission, have been named by President Roosevelt as members of the Tennessee Valley Authority. Recently the President named Arthur E. Morgan, president of the Dayton Morgan Engineering Co. and president of Antioch College, Dayton, Ohio, chairman of the board of three making up the Tennessee Valley Authority.

Mr. J. H. A. Morgan is a native of Canada and a graduate of the University of Toronto and of Cornell University where he specialized in etymology and horticulture. He became director of the University of Tennessee, Agricultural Station, in 1904 and dean of the College of Agriculture in 1913. Mr. Lilienthal is a lawyer and former lecturer on public utility law at Northwestern University. He was appointed to the Wisconsin Public Service Commission in 1931.

North Carolina Plans Adoption of a State Building Code

The North Carolina building code council composed of 125 engineers, architects, contractors and building officials, formed in 1931 to prepare and work for the adoption of a state building code, has completed its work and secured legislative approval for putting it into effect. According to W. G. Geile, associate professor of construction engineering, North Carolina State College, who was instrumental in forming the building code council, and active in its work, the legislature was not asked to adopt the code, but instead was asked for the appointment of an official building code council with power to adopt rules and regulations governing construction. A bill incorporating these aims was drawn up and passed by the legislature without a dissenting vote. (A similar measure has also been enacted by the general assembly of South Carolina.)

In North Carolina the council, to be appointed by the Governor, will be composed of five members, one architect, one engineer, one general contractor, one plumbing and heating contractor, and one representative of labor, all to be registered where registration laws apply. The rules and regulations adopted by them are to be enforced through the office of the insurance commissioner. The council will also act in an advisory capacity to the commission in interpreting the code. Members of the council are to serve without pay from the state, but the law stipulates that they may receive compensation from the organization which they represent, such as the various licensing boards of the state.

It is anticipated that the appointed building code council will adopt the proposed code, as prepared by the present unofficial council.

The proposed code does not apply to dwellings, farms buildings, and other structures of minor importance. It calls for certification of plans and specifications, and it is hoped that the appointed council will also require that plans and specifications be prepared by registered architects or engineers. There is a question as to whether or not the adoption of the last requirement would be legal, according to Professor Geile. He also states that it is planned that the existing building code council change its name to the North Carolina Building Congress, widen its field and carry on the work of promoting the interests of the building industry of the state.

Long Bridge and Tunnel Project at St. Petersburg, Fla., Approved

The Governor of Florida, on May 29, approved a bill granting a franchise to the West Coast Bridge & Tunnel Co., for the construction and operation of a bridge and tunnel across Tampa Bay from the intersection of 4th and 66th Ave. South in St. Petersburg to Piney Point in Manapee County, Fla. The proposed bay crossing will consist of six miles of bridge and one mile of tunnel under the navigable channel. It is proposed to build a tunnel of precast units sunk in a trench across the channel. The estimated cost is placed at $7,500,000. Under the franchise the right-of-way has to be secured within 12 months, the company must give bonds within 30 months and within 18 months after the bond is given 25 per cent of the work must be completed.

Construction of the bay crossing will decrease the distance between St. Petersburg and Bradenton by about 50 miles. It will form a link in the West Coast highway from St. Petersburg to Mobile.

Concrete Placing Begins on Golden Gate Bridge Pier

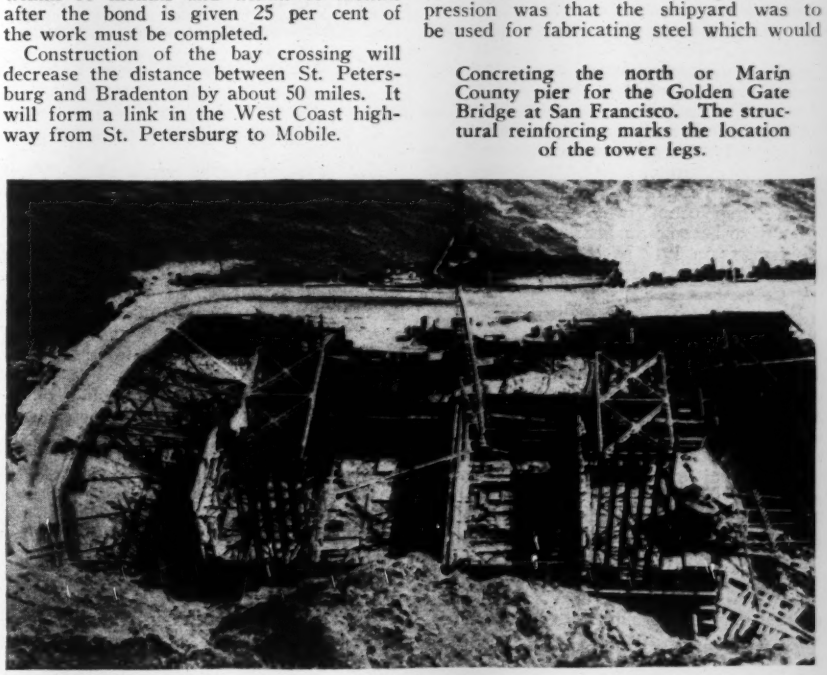
Concrete placing has started on the north (Marin County) pier of the Golden Gate bridge. Batching of aggregate and cement is done at a water-side plant supplied by barge and the material is mixed in mixer-body trucks enroute to the site. This plant and mixing arrangement will also be used for the anchorage and a duplicate setup for concreting has been completed on the San Francisco side.

On the south (San Francisco) end of the bridge site the principal work has been confined to the excavation operations at the pier location, 1,000 ft. from the shore in about 50 ft. of water. After the construction of a 1,000-ft. trestle to the pier site, involving the blasting of foundations for the bents in rock, excavation was started over the area. Using the trestle for transporting supplies and equipment, the work has involved subaqueous blasting with removal of the loosened rock by barge-mounted dredge and overcasting into deep water. About half of the yardage from the fender and pier site has been removed.

Excavation for the north anchorage has been completed and the site is ready for concrete. Work at the south anchorage site has been complicated by buildings in the military reservation and the need for moving a section of the existing seawall. This preliminary work has been almost finished and excavation of the site is in progress.

A demand by civic groups that the proposal of the steel contractor to use a shipyard in Alameda (outside the district) be met with a requirement that such work should be done in San Francisco, has been turned down by the board of directors of the district. The controversy, which resulted in the temporary withholding of a payment due McClintic-Marshall while the matter was studied by the board, was caused by a misunderstanding of the work to be done at the site. The general impression was that the shipyard was to be used for fabricating steel which would

Concreting the north or Marin County pier for the Golden Gate Bridge at San Francisco. The structural reinforcing marks the location of the tower legs.



have involved the use of labor and materials outside of the district. It was shown, however, that the yard was to be used primarily for storing shapes fabricated in the east and that the crew would be small, in addition to the fact that there was no suitable plant available on the San Francisco side of the bay. As a result of this finding by the board the progress payment was authorized.

City and district authorities are studying the plan for a new approach artery to improve the traffic conditions in San Francisco over those that will result if the original route is adhered to. This effort is complicated by the necessity of having to secure federal approval of a new route through the military reservation and the further need to have the change approved by the state legislature. The proposed route would save distance and provide for a better distribution of traffic entering San Francisco.

Proposed 236-Mile Rail Line Disapproved by Commission

The Interstate Commerce Commission, on May 31, declined to approve the application of the St. Louis-Kansas City Short Line Railroad Co. for a loan of $35,000,000 from the Reconstruction Finance Corporation for the construction of a railway line 236 miles long between St. Louis and Kansas City. The company was incorporated in 1924 and is reported to have acquired 172 miles of right-of-way and to have done some preliminary engineering for a high-speed electrified railway between the two cities.

Fred A. Noetzli, Specialist in Dam Design, Dies

Fred A. Noetzli, consulting hydraulic engineer, Los Angeles, Calif., died at Covina, Calif., on May 24 of a heart ailment. Mr. Noetzli had been in ill health for some time and three months ago had gone to his home in Covina to rest.

Mr. Noetzli was born in Switzerland in 1887 and graduated from the Swiss Federal Polytechnic Institute at Zurich in 1911 as a civil engineer. Two years later he received a doctor of science degree from the same institute. After teaching and professional work in Switzerland and in Italy, Mr. Noetzli, in 1914, came to this country to become an instructor in Lehigh University; in 1917 he became chief engineef of the Beckman & Linden Engineering Corp., San Francisco.

Returning to Europe in 1922 Mr. Noetzli spent a year in investigation work and then came back to this country to specialize in dam design. Mr. Noetzli served as consulting engineer to the U. S. Indian Service on the design and construction of Coolidge dam, as consultant to the Los Angeles Flood Control District upon several of its high dams, also as consultant to the city of Pasadena on the Pine Canyon dam. He also was consulting engineer to the Mexican Government on the Rodriguez dam.

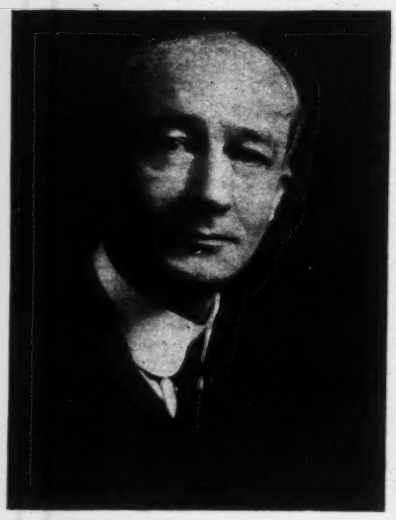
Mr. Noetzli took an active part in the work of the arch dam investigation carried on by the Engineering Foundation, serving as its secretary from 1922 until 1933.

Sewage Plant for Bowling Green

The Reconstruction Finance Corp., on May 27, authorized the re-allocation of $70,000 of the $660,000 loan authorized to the city of Bowling Green, Ky., on Nov. 10, 1932, for a sewer system. The original loan was expected to cover only the cost of the sewer system and some temporary septic tanks, but since the loan was approved the city has received such favorable bids on the work that it now finds that it can substitute for the septic tanks coarse screens, two Imhoff tanks, and sludge beds, with a capacity of 3,800,000 gal. per day.

Henry H. Wilson Dies; Long Active in Construction

Henry H. Wilson, of Harrisburg, Pa., president of the Pennsylvania Construction Council and chairman of the executive committee of the Associated Pennsylvania Constructors, died at Johns-Hopkins Hospital in Baltimore on May 31 of bronchial pneumonia. Mr. Wilson sustained an injury to his back on April 25 and had gone to the hospital for observation and treatment.



Henry Harrison Wilson

Mr. Wilson was 51 years old. After graduating in civil engineering from Virginia Polytechnic Institute in 1906 he entered the employ of Winston & Co. As construction engineer for that concern he served on many projects, including the Ashokan dam and the head-works for the Catskill aqueduct of the New York City water supply. Subsequently Mr. Wilson became a special partner in the same company and as such handled a large amount of highway, railroad and other engineering construction in the eastern states. In 1927 he became affiliated with Winston Bros. Co., Minneapolis, under the firm name of Winston Bros. Co., and H. H. Wilson, Harrisburgh, Pa.

Mr. Wilson was widely known throughout the country because of his activity in connection with construction associations. He was one of the organizers of the Associated Pennsylvania Constructors, of which he was the first president, and subsequently became chairman of the executive committee and general manager, a position which he held continuously to the time of his death. For 12 years he served as a director of the Associated General Contractors of America and has been a director of the American Construction Council since its organization. For the past two years he served as chairman and later as president of the Pennsylvania Construction Council, and also was chairman and editor of the *Highway Builder*, the monthly magazine of the Associated Pennsylvania Constructors.

Railroad Track Relocation at Buffalo Postponed

The project for relocating railroad tracks within the city of Buffalo, N. Y., taken up actively by the city council about three years ago, has been abandoned temporarily on account of the opposition of the railroads concerned to making the expenditure required. As a consequence the council, by mutual agreement, has cancelled the 10-year contract entered into with the engineering firm of George P. Diehl, Inc., under which the firm was to take charge of the work for the city for a fixed annual fee. Under the new agreement, the firm will be re-engaged in case the city decides to take up the work in the future.

Waterworks Association Men Prepare for Recovery Act

Feeling that all subdivisions of the nation will be called upon to initiate projects which may be carried out under the provisions of Title II of the National Industrial Recovery Bill a dozen members of the American Waterworks Association met May 19 at Lafayette, Ind., and formulated plans tentatively to take full advantage of the provisions of the bill. The conference was activated by the belief that it is the duty of waterworks personnel to provide all possible work on needed waterworks construction.

As a result of the conference the section secretaries have been instructed to come to the Chicago convention June 12 bringing with them information of the following possible work of all towns in their territory over 1,000 population: 1. Complete installations where none now exists. 2. New supply works or betterments. 3. New filters. 4. Elevated storage. 5. Reinforcement of the distribution system necessary to proper fire protection. 6. Extension of mains. 7. Meterization. 8. New equipment including that for laboratories, reservoir pumps, master meter facilities for proper records, trucks and repair and construction machinery.

Other matters to be discussed by the secretaries at Chicago relate to Title I of the bill in case it may be applied to the waterworks business. They include wage scales, waterworks personnel of proper qualification, registration of operators or other means to insure proper operation.

It is not contemplated that the secretaries will be able to comply fully with the requirements of this program in the brief time before June 12, but it is hoped to lay the foundation for a crystallization of ideas at the convention.

The whole matter is being considered in its relation to the national emergency, with the waterworks industry in a strategic position.

Bids Accepted for Large Dam on the White Nile in Egypt

The Egyptian Government has accepted a tender of £2,078,000 (Egyptian money) submitted by J. W. Gibson, London, England, for the construction of Gebel Aulia dam on the White Nile in Egypt. Mr. Gibson was agent for S. Pearson & Sons, Ltd., London, on the construction of the Sennar dam. Under the agreement, Mr. Gibson has to form a company to carry out the project which must be both financially sound and familiar with construction work. The dam is both for irrigation and power.

Bids on the dam were received by the Egyptian Government in March (ENR, March 30, p. 419). The bid of the firm of Pauling & Co., London, was somewhat lower than that of Mr. Gibson, being £2,074,581.

Coode, Wilson, Mitchell & Vaughan-Lee, Westminster, England, are engineers.

Dabney H. Maury: 1863-1933

The death of Dabney H. Maury on May 11 was noted briefly in these columns on May 18. Fuller information concerning his engineering career has been obtained from F. G. Gordon, his partner in Chicago for many years, and is given below.

Following a year on mine property after his graduation from Stevens Institute of Technology in 1884 Mr. Maury became principal assistant engineer on location and construction of the Fort Worth & New Orleans Ry. 1885 and 1886. Subsequently he was superintendent of land surveys for the Southern Pacific in western Texas for a few months but resigned that position to accompany his father, Gen. Dabney H. Maury, then minister to the Republic of Colombia, South America. Engineering work there interested him and he remained in Colombia until 1892 as engineer and general manager of various mine properties.

Mr. Maury's next engineering engagement was as engineer and superintendent, Peoria (Ill.) Water Works Company from 1893 to 1912. In the latter year he opened an office for consulting practice in Chicago.

From 1917 to 1919 Mr. Maury, as a major in the army, was advisory engineer on water supply for the construction division in charge of design of water supplies for all projects under that division; was borrowed by the Marine Corps for water supplies at Paris Island and Quantico and by the Navy for water supplies at Pearl Harbor and other points in Hawaiian Territory; and finally was assigned by War Industries Board to the development of joint water supplies for the Army, Navy, Shipping Board and Housing Corporation in Hampton Roads district. From then on until his retirement Major Maury maintained his consulting office in Chicago. Upon retirement he moved to Chevy Chase, Md.

Engagements in civil life extended to more than 200 cities. Mr. Maury held several patents on wells and pumping machinery, was an expert on electrolysis involving water mains and was a frequent contributor to the technical press and societies, winning in 1920 the James Laurie prize of the American Society of Civil Engineers.

Engineers' Convention Specials

Two special trains for members of the civil, mining, mechanical, and electrical engineering societies and members of the American Society for Testing Materials are to be run by the Baltimore & Ohio Railroad from New York to Chicago on Saturday, June 24, and Sunday, June 25. The Saturday train will leave the Jersey City terminal at 10:30 a.m. (standard time) and will arrive in Chicago at 8:30 a.m., and the Sunday train will leave Jersey City at 11:15 a.m. and arrive in Chicago at 8:45 a.m. Monday. Stops will be made for passengers at Newark, Elizabeth, Philadelphia, Baltimore, Washington and Pittsburgh.

SOCIETY CALENDAR

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Chicago, Edgwater Beach Hotel, June 26-30.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Chicago, Palmer House, June 27-30.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Chicago, Palmer House, June 27-July 1.

AMERICAN SOCIETY OF MUNICIPAL ENGINEERS, Milwaukee, Wis., Sept. 25-27.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Chicago, Stevens Hotel, June 26-30.

AMERICAN WATERWORKS ASSOCIATION, annual meeting, Chicago, June 12-16.

NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS, annual convention, Chicago, Stevens Hotel, June 26-28, 1933.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, annual meeting, Chicago, Stevens Hotel, June 27-30.

ENGINEERS WEEK, Century of Progress Exposition, Chicago, June 26-July 1.

Brief News

A NEW RECORD for traffic over the George Washington Bridge at New York was established on Sunday, June 4, when 37,228 vehicles passed over the bridge. The previous record was 37,016 on May 15 of last year.

DEEPENING OF SOUTH HAVEN HARBOR, Michigan, at an estimated cost of $67,500 has been approved by the War Department. The project calls for a channel 150 ft. wide and 19 ft. deep, also a turning basin 375 ft. wide. Maintenance is estimated to cost $10,000 per year.

AN AGREEMENT BETWEEN THE DIRECTORS of the Reconstruction Finance Corporation and the Niagara Frontier Bridge Authority under which the R.F.C. will advance money for the construction of the Grand Island bridges near Buffalo, N. Y., has been concluded and now awaits only the assurance that land needed for the right-of-way for the bridges can be obtained from private owners at a reasonable figure. Some property owners have donated land for the project. The county board of supervisors has appropriated $250,000 for right-of-way.

CONSTRUCTION MATERIALS will be affected by the new sales tax bill recently introduced into the General Assembly of the State of Illinois to replace the sales tax recently declared invalid by the state supreme court. The tax applies to all retail sales. The previous act exempted farmers selling their own products and gasoline which already is taxed. As introduced, the bill provided for a 3 per cent tax but it was subsequently amended to a 2 per cent tax.

THE INTERSTATE PORT AUTHORITY for the development of the Illinois-Indiana shore line, noted in our issue of May 25, p. 700, was established to consider the Michigan lake front between Michigan City, Ind. and Waukesha, Ill. The purpose of the Port Authority was incorrectly stated in our issue of May 25.

CONSTRUCTION OF A MUNICIPAL LIGHT PLANT at a cost of $500,000 was approved by voters of Brawley, Calif., at a special election June 1. The city now receives electric service from the Southern Sierras Power Co. The vote was 901 to 465. The city proposes construction of a Diesel engine power plant to be paid for out of income. Brawley is the first Imperial Valley town to enter upon a municipal electric plant program.

Personal Notes

RAYMOND A. ORPUT has been appointed city engineer of Rockford, Ill., succeeding L. A. WILSON.

JACK JONES has been named city engineer of Longview, Wash., to succeed GEORGE E. HOPKINS, who has resigned to accept a position with the Longview Co.

OTIS E. HOVEY, consulting engineer, American Bridge Co., was awarded the honorary degree of Doctor of Science by Clarkson College of Technology, Potsdam, N. Y., on May 29.

HARLEY LATSON, captain, Corps of Engineers, U. S. Army, recently a student at the army school at Fort Leavenworth, Kansas, has been assigned to the Memphis Engineer District with headquarters at Memphis.

L. R. PLEMMONS has been appointed city engineer of Hot Springs, Ark., to succeed A. F. ANNEN. Mr. Plemmons is a graduate of the University of Arkansas and for the past six years has been district engineer for the Arkansas highway department at Camden, Ark.

E. E. TALMADGE has been appointed manager, engineering department, General Electric Realty Corp., Schenectady, N. Y. In this position Mr. Talmadge will have charge of design, construction and maintenance of buildings for the General Electric Co.

LEON S. MOISSEIFF has been awarded the Louis Edward Levy medal of the Franklin Institute, Philadelphia, for his paper entitled "The Design, Materials and Erection of the Kill van Kull (Bayonne) Arch." published in the May, 1932 issue of the Journal of the Institute.

A. CHARLES WAGHORNE and MAURICE F. BROWN have formed a partnership to carry on a contracting business specializing in steel construction under the name of Waghorne-Brown Co., 44 School St., Boston, Mass. Mr. Waghorne is an engineering graduate of Tufts College and recently was vice-president in charge of the Boston office of the Palmer Steel Co. Mr. Brown is a graduate of Thayer School

of Civil Engineering and Dartmouth College. For 25 years prior to 1928 he was chief engineer of the Boston Bridge Works. Since 1928 he has been in private practice.

A. E. STOCKBURGER, city manager of Alhambra, Calif., has resigned that position to become the first city manager of Ventura, Calif. Mr. Stockburger is an engineering graduate of the University of Arkansas.

GLENN D. MACY, engineer in charge, District No. 2, New Mexico state highway department, was appointed state highway engineer of New Mexico on April 8 to succeed W. R. ECCLES. Mr. Macy is a graduate of Ohio State University and entered the highway department of New Mexico in 1923 as assistant state highway engineer, subsequently becoming district engineer at Roswell.

Obituary

ERNEST W. DANFORTH, former city engineer of Somerville, Mass., died at Brunswick, Maine, on June 2, age 61 years. Mr. Danforth was a graduate of the University of Maine and had been in the Somerville engineering department for about 35 years.

JUNIUS W. JOHNSON, district engineer, Bureau of Public Roads, Denver, Colo., died on May 31 on a train en route to Denver from an inspection trip in Wyoming. Since 1921 Mr. Johnson had been in charge of District 3, which includes Wyoming, Colorado and New Mexico. Born in Kentucky in 1878, he graduated from the School of Mines at Golden, Colo. in 1901. Subsequently he was on railroad location work, assistant city engineer at Denver, and in private practice. In 1909 he was appointed deputy state engineer in charge of road and bridge work. In 1913 he became assistant state engineer of New Mexico in charge of all road and bridge work and four years later was appointed senior highway engineer of the Bureau of Public Roads. From 1929 to 1932 Mr. Johnson was in Washington to supervise the construction of the Mount Vernon Memorial Highway.

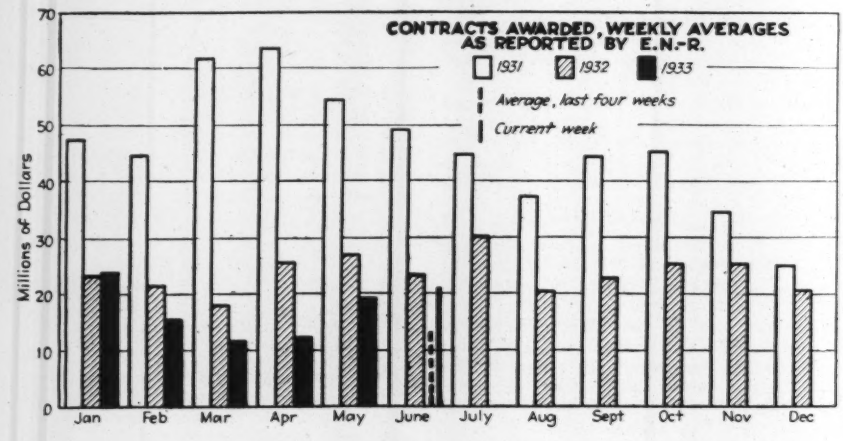
PHILIP J. REICH, assistant chief engineer of the American Bridge Co., Pittsburgh, Pa., died there suddenly on May 31 following an operation for appendicitis. Mr. Reich was appointed to the position of assistant chief engineer in January of this year. He graduated from Purdue University in the class of 1899 and went immediately to the bridge department of the Illinois Ceneral R. R. A year later he went to the Toledo Bridge Co. and in 1901 joined the draughting department of the Toledo plant, American Bridge Co. Since that time, except for two years with the Riverside Bridge Co. at Wheeling (1904-1906), Mr. Reich has been with the American Bridge Co. He served as plant engineer of the Toledo plant from 1906 to 1920 and as division engineer, central division, Pittsburgh, from 1920 to 1933.

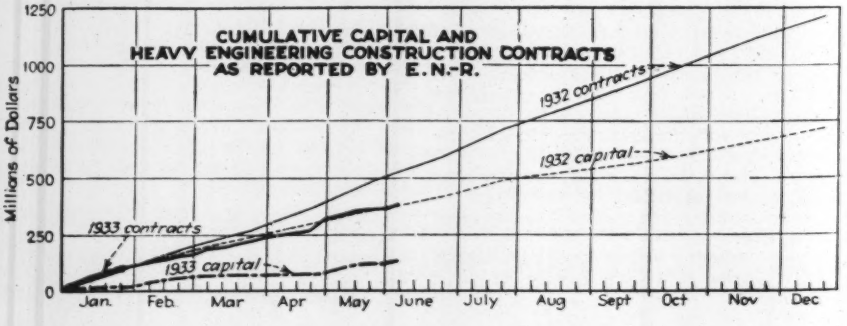
ALVIN E. GEMPLER, county engineer at Mt. Vernon, Ind., died recently at Evansville, age 43 years. During the war Mr. Gempler served in the Engineer Corps and following the war spent some time in the government engineering service. He was a graduate of Indiana University.

Engineering Contracts and Capital

HEAVY engineering construction contracts reported during the past week total $21,511,000, a gain of 3½ millions over the previous week and a total three times as large as awards reported two weeks ago. The week's total is 50 per cent greater than the average of contracts let during the past four weeks. Award of additional tunnels on the Colorado River aqueduct, $4,324,000, the Rip Van Winkle bridge across the Hudson River, $2,165,000, irrigation works in Arizona, $3,191,000 and a hospital in Baltimore, $1,208,000 helped to swell the week's contract figures. Public works awards amounted to $13,901,000, as compared with $2,900,000 the previous week. Federal contracts were the heaviest in four weeks, amounting to $1,170,000, following a low total of $117,000 the week before. Highway lettings were the heaviest in ten weeks with a total of $3,294,000. Public buildings awards were the largest in five weeks, aggregating $1,789,000. Private contract awards, $7,610,000, while far behind the previous week's exceptional figure of $15,000,000, were way above the average for this class of work. Cumulative contracts to date this year total $380,901,000, about 72 per cent of the total of contracts let in the same period of last year.

New productive capital issues reported sold during the week amounted to $6,135,000, all public issues. Cumulative new capital totals for the year are far behind those of last year to date, amounting to $131,560,000, as compared with a total of $369,600,000 for 1932.





Contracts and Capital

CONSTRUCTION
(Thousands of Dollars)

	Weekly June, 1932	Average Four Weeks	Week June 8, 1933
Federal government	$6,384	$550	$1,170
State and municipal	12,002	5,719	12,731
Total public	$18,386	$6,269	$13,901
Total private	5,331	7,473	7,610
Week's total	$23,717	$13,742	$21,511
Cumulative todate:			
1932		$526,962	
1933		380,901	

NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

	Weekly June, 1932	Average Four Weeks	Week June 3, 1933
New capital issues	$12,600	$7,471	$6,135
Cumulative to date:			
1932		$369,600	
1933		131,560	
R.F.C. self-liquidating loans:			
Approved curren week			
Approve t date (including 1932)			$202,071
Actual loans made (including 1932)			47,195

ENR Cost and Volume Index

E.N.-R. Cost		E.N.-R. Volume	
June, 1933	**163.41**	**May, 1933**	**103**
May, 1933	164.39	April, 1933	65
June, 1932	152.20	May, 1932	149
1932 (Average)	156.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.35	1930 (Average)	260
1913 Average		100	